NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

THESIS

ASSESSING THE OPERATIONAL VALUE OF SITUATIONAL AWARENESS FOR AEGIS AND SHIP SELF DEFENSE SYSTEM (SSDS) PLATFORMS THROUGH THE APPLICATION OF THE KNOWLEDGE VALUE ADDED (KVA) METHODOLOGY

by

Joseph Uchytil

June 2006

Thesis Advisor:	Thomas J. Housel
Second Reader:	Glenn R. Cook

Approved for public release; distribution is unlimited

THIS PAGE INTENTIONALLY LEFT BLANK

REPORT DOCUMENTATION PAGE			*Form Approved OMB No. 0704-0188*
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instruction, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188) Washington DC 20503.			
1. AGENCY USE ONLY *(Leave blank)*	**2. REPORT DATE** June 2006	**3. REPORT TYPE AND DATES COVERED** Master's Thesis	
4. TITLE AND SUBTITLE: Assessing the Operational Value of Situational Awareness for AEGIS and Ship Self Defense System (SSDS) Platforms through the Application of the Knowledge Value Added (KVA) Methodology			**5. FUNDING NUMBERS**
6. AUTHOR(S) Joseph Uchytil			
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Postgraduate School Monterey, CA 93943-5000			**8. PERFORMING ORGANIZATION REPORT NUMBER**
9. SPONSORING /MONITORING AGENCY NAME(S) AND ADDRESS(ES) N/A			**10. SPONSORING/MONITORING AGENCY REPORT NUMBER**
11. SUPPLEMENTARY NOTES The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. Government.			
12a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release; distribution is unlimited			**12b. DISTRIBUTION CODE**

13. ABSTRACT (maximum 200 words)

As the United States Navy strives to attain a myriad of situational awareness systems that provide the functionality and interoperability required for future missions, the fundamental idea of open architecture is beginning to promulgate throughout the Department. In order to make rational, informed decisions concerning the processes and systems that will be integrated to provide this situational awareness, an analytical method must be used to identify process deficiencies and produce quantifiable measurement indicators.

This thesis will apply the Knowledge Value Added methodology to the current processes involved in track management aboard the AEGIS and Ship Self Defense System (SSDS) platforms. Additional analysis will be conducted based on notional changes that could occur were the systems designed using an open architecture approach. A valuation based on knowledge assets will be presented in order to provide a comparative analysis, detailing how knowledge assets can be leveraged in the most efficient and effective manner.

14. SUBJECT TERMS Information Systems Technology, Track Management, Situational Awareness, Knowledge Value Added, Return on Knowledge, Knowledge Assets, Open Architecture, Combat Identification, Metrics.			**15. NUMBER OF PAGES** 91
			16. PRICE CODE
17. SECURITY CLASSIFICATION OF REPORT Unclassified	**18. SECURITY CLASSIFICATION OF THIS PAGE** Unclassified	**19. SECURITY CLASSIFICATION OF ABSTRACT** Unclassified	**20. LIMITATION OF ABSTRACT** UL

NSN 7540-01-280-5500 Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. 239-18

THIS PAGE INTENTIONALLY LEFT BLANK

Approved for public release; distribution is unlimited

ASSESSING THE OPERATIONAL VALUE OF SITUATIONAL AWARENESS FOR AEGIS AND SHIP SELF DEFENSE SYSTEM (SSDS) PLATFORMS THROUGH THE APPLICATION OF THE KNOWLEDGE VALUE ADDED (KVA) METHODOLOGY

Joseph S. Uchytil
Captain, United States Marine Corps
B.S., San Diego State University, 1997

Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN INFORMATION TECHNOLOGY MANAGEMENT

from the

NAVAL POSTGRADUATE SCHOOL
June 2006

Author: Joseph S. Uchytil

Approved by: Dr. Thomas J. Housel
Thesis Advisor

Glenn R. Cook
Second Reader/Co-Advisor

Dr. Dan C. Boger
Chairman, Department of Information Sciences

THIS PAGE INTENTIONALLY LEFT BLANK

ABSTRACT

As the United States Navy strives to attain a myriad of situational awareness systems that provide the functionality and interoperability required for future missions, the fundamental idea of open architecture is beginning to promulgate throughout the Department. In order to make rational, informed decisions concerning the processes and systems that will be integrated to provide this situational awareness, an analytical method must be used to identify process deficiencies and produce quantifiable measurement indicators.

This thesis will apply the Knowledge Value Added methodology to the current processes involved in track management aboard the AEGIS and Ship Self Defense System (SSDS) platforms. Additional analysis will be conducted based on notional changes that could occur were the systems designed using an open architecture approach. A valuation based on knowledge assets will be presented in order to provide a comparative analysis, detailing how knowledge assets can be leveraged in the most efficient and effective manner.

THIS PAGE INTENTIONALLY LEFT BLANK

TABLE OF CONTENTS

THIS PAGE INTENTIONALLY LEFT BLANK

LIST OF FIGURES

THIS PAGE INTENTIONALLY LEFT BLANK

LIST OF TABLES

THIS PAGE INTENTIONALLY LEFT BLANK

ACKNOWLEDGMENTS

I would like to thank Dr. Thomas Housel and Professor Glenn Cook for their astute guidance and mentorship. The process of researching and writing this thesis provided me with a learning experience that was made possible only through their support and direction.

To Captain James Shannon (USN), Lieutenant Commander Scott Corsano (USN), Mr. William Johnson and Mr. Mark Wessman, without whose cooperation this research could not have been conducted. Your willingness to extend whatever support was required was vital to the completion of my thesis and I am truly grateful.

To Ms. Maritza Zuluaga, whose coordination was instrumental for obtaining points of contact and arranging meetings. Her efforts were more than helpful and I am grateful for having had the opportunity to work with her.

The list of subject matter experts at Naval Surface Warfare Center, Dahlgren was extensive and I am grateful for all their insight and cooperation. Ed Gohring, Mike Pepe, and Ken Pierson were standouts, providing a multitude of historical data and a wealth of knowledge from their many years of experience.

Finally, to my wife, Katherine, without whose support and understanding I would ever have been able to accomplish this task.

THIS PAGE INTENTIONALLY LEFT BLANK

I. INTRODUCTION

A. PURPOSE

While operational capabilities are used to determine requirements documents for combat systems, the acquisition process must take into account costs and schedule when providing these systems to the Fleet. Information technology systems are subsequently measured through an analysis of return on investment, utilizing a monetary metric. This analysis of return does not adequately account for the value the system can provide to the operator, nor does it account for any additional efficiencies that could be incorporated in future designs. Operational value should not be measured only through cost savings, return on investment or financial metrics, but rather the additional capabilities that are leveraged through the application of IT. A tactical operator does not value a system by how much it cost, or if it will produce a financial return on investment, but rather whether the system can provide a more timely and efficient means to accomplish the mission.

The purpose of this research is to determine if a knowledge value-added (KVA) methodology can measure the operational value of a system, and where deficiencies can be identified and processes improved to provide a more robust and capable information technology system to the war fighter. A current initiative known as Navy Open Architecture (OA) seeks to leverage commercial technology, non-proprietary standards and software reuse to reduce multiple architectures and improve interoperability. A realization of this initiative may provide huge dividends through implementing an approach to development of situational awareness systems aboard naval vessels. Open architecture is predominantly associated with providing more capabilities in the design and maintenance of information technology systems, and budgetary constraints with systems design and development.

B. BACKGROUND

Track management is the process by which friendly and enemy forces are detected, identified, monitored and updated and communicated throughout the area of operations. This is a fundamental capability that is inherent in all naval ships to some extent.

Historically, track management was conducted through the use of grease pencils and wall charts. As advances in technology increased, automation through information technology became the norm. With the advent of the AEGIS platform, multiple sensors and data links were fused to provide a comprehensive situational awareness of all tracks within a given area of responsibility (AOR). While the AEGIS system, and later SSDS, platforms significantly enhanced the track management capabilities of surface ships, they were created based on a proprietary architecture which was characterized by stovepipe systems that were neither scaleable nor interoperable. Open architecture provides a means to propel the Navy into the next century and an era of joint interoperability.

In an era where technological development outpaces the current procurement process, the United States Navy must implement a strategy that will enable operational capabilities to remain at the forefront of naval warfare. Current legacy systems utilizing a closed, proprietary architecture in hardware and software greatly limit operational capabilities that could be generated through interoperability and collaborative processes that current technology can provide. "Stovepipe" systems built are difficult to upgrade and provide limited interoperability with other systems. As technology continues to define requirements for combat effectiveness, the operational forces are required to continue to keep up with a multitude of systems that are woefully inadequate in the realm of interoperability and functionality.

The key to United States dominance in any conflict, as discussed by the Chairman of the Joint Chiefs of Staff in Joint Vision 2020, will be "decision superiority." Decision superiority can be defined as "translating information superiority into better decisions arrived at and implemented faster than an enemy can react." To achieve information superiority, the Department of Defense has been engaged in the development of a Global Information Grid (GIG) which will provide the environment for decision superiority. As the Department of Defense continues to strive for a more joint operational environment, the United States Navy will need to develop architectures to meet the integration challenges that will be required for integration into the Global Information Grid.

C. RESEARCH OBJECTIVES

The objective of this research is to analyze the AEGIS and SSDS track management systems to determine potential operational benefits that could be realized through the application of an OA approach to system design. Through an application of a knowledge value-added methodology, knowledge assets inherent in the core processes of a system can be identified, quantified and subsequently valued.

The methodology provides a return on knowledge or ROK (a ratio which measures the knowledge assets resident in a system through its decomposition into the common units of output the knowledge asset produces). This commonality can then be used in the assessment of multiple systems within a common domain.

D. RESEARCH QUESTIONS

There are no current measurements or metrics that can effectively provide a defensible return on investment estimate at the sub corporate level with regards to a system's operational value. Current methodologies are applicable to procurement, maintenance and lifecycle costs, but are insufficient when determining actual value of a system to an operator.

This research study will provide insight into whether OA can improve operational value in a situational awareness system. Of interest will be whether 1) KVA can be applied to estimate the value of the current track management systems on the AEGIS and SSDS platforms, 2) the resulting ROK can be used to determine areas where OA may provide increased efficiency, and for future research 3) real options analysis can be used to support decisions regarding functional integration of current platforms into future systems. These questions will be analyzed using the KVA and Real Options methodologies to address these issues.

E. METHODOLOGY

This thesis will model the current track management processes found within both the AEGIS and SSDS platforms and apply the KVA methodology to them in order to determine an "As Is" process performance baseline. The processes for the current systems will be derived from process flow diagrams, use-case diagrams, interviews with subject matter experts (SME) and literature review of pertinent documents. The resulting return on knowledge will be analyzed from an operational perspective with respect to a "To Be" process generated from an OA design.

Both the “As Is” and “To Be” process analysis will be conducted utilizing the “learning time” approach to KVA (explained later in this thesis). The core elements of “time-to-learn”, “number of personnel involved”, and “times fired” will produce a ratio of the performance of knowledge assets in each process. This ratio (ROK) provides a common unit of measurement to generate the numerator (i.e., value estimate), and is used subsequently for each sub process within the track management process.

F. SCOPE

The scope of this thesis will be limited to the operational value that OA can provide to the Fleet with respect to the situational awareness process. Though greater value from open architecture may be in its labor saving and cost saving attributes for acquisition and maintenance, this research is focused on the knowledge capital inherent in the current systems and how an understanding of this can provide insight into future efficiencies based on an OA approach to systems development at the operator level.

G. THESIS ORGANIZATION

This thesis will be organized in the following manner:

Chapter I will provide an overview of the thesis with regard to purpose and scope. Additionally, research questions and objectives will be provided, along with the methodology used to generate the final conclusions. Chapter II is provided for a background understanding of open architecture, how the concept is applied within the Navy, and how it may be applied to the research. This chapter provides the foundation for the information needed to complete the research and draw conclusions. Chapter III outlines the KVA methodology so as to provide a basic understanding of the concept of knowledge capital and how return on knowledge is derived. Chapter IV is a detailed synopsis of the research conducted, findings and KVA analysis. This chapter is the crux of the thesis and puts the other chapters into operational perspective. Chapter V presents conclusions, real options analysis and any recommendations to the Navy that may be derived from the research.

II. OPEN ARCHITECTURE ENVIRONMENT

A. GENERAL

The Government Accountability Office (GAO) recently addressed the inadequacy of legacy systems within the Department of Defense (DOD) with regard to interoperability: "Despite recent progress by the Department of Defense, military operations continue to be hampered by command, control, and communications systems that lack the ability to interoperate" (GAO-06-211, 2006). The report further noted that "rather than being developed around integrated architectures and common standards, systems have been designed and developed using different standards and protocols" (GAO-06-211, 2006), which limits their interoperability and ability to exchange information horizontally vice vertically. With the inception of "Sea Power 21", the Chief of Naval Operations (CNO), Admiral Vernon Clark, stated that "…future naval operations will use revolutionary information superiority" (*Proceedings*, 2002). The idea of information superiority was to be achieved through the application of FORCEnet, which is "an overarching effort to integrate warriors, sensors, networks, command and control, platforms and weapons into a fully netted, combat force." This issue was addressed in 2003 by Vice Admirals Richard Mayo and John Nathman in a *Proceedings* article regarding the FORCEnet architecture whereby they commented on "…standard joint protocols, common data packaging, seamless interoperability, and strengthened security" (*Proceedings*, 2003) as requirements for FORCEnet to become an enabler of Sea Power 21. To accomplish these tasks, the Navy must adhere to an open architectural framework which will enable effective interoperability and scalability required of the Global Information Grid (GIG) and net centric warfare.

These new visions permeated the U.S. Navy and resulted in the creation of the Program Executive Office, Integrated Warfare Systems (PEO IWS) in 2002. This office is charged with implementing the Navy's Open Architecture (OA) strategy through the adoption of standards, products and best practices to ensure that future surface and submarine combat systems will allow for integration and future technological insertion.

B. DEFINING OPEN ARCHITECTURE

Open architecture, as defined by the Open Systems Joint Task Force (OSJTF) is one "that employs open standards for key interfaces within a system", where open standards are ones which "are widely used, consensus based, published and maintained by recognized industry standards organizations", and key interfaces are "common boundaries shared between system modules that provides access to critical data, information, materiel, or services; and/or are of high interest due to rapid technological change, a high rate of failure, or costliness of connected modules" (www. http://www.acq.osd.mil/osjtf/termsdef.html). With this concept in mind, the Navy's surface ship community defined OA as "a system architecture and the architectural components of a system that conform to open system standards and possess the other open systems attributes" (OACE Guidance Document).

1. OA Attributes

An open architecture framework should provide principles and guidelines which will enable open systems to be designed and evolved over the course of their life cycle. To accomplish this, open architecture provides a core group of concepts that must be addressed in order to achieve mission requirements. These concepts, while not all encompassing, provide the foundation for the open architecture framework.

a. Modularity

One of the underpinnings of an open architecture is the adherence to modularity, or modular programming. This concept is characterized by the decomposition of a system into smaller subsystems, or components, which are independently operable, subject to change and provide for interaction with each other through interfaces. These components, each with their own set of independent characteristics, perform specific functions for the system and, upon completion, return control back to the system. Each of these components can be developed, tested and upgraded independently, enabling greater functionality within the entire system. This concept is represented in Figure 1. Modularity lends itself to software reuse which is also considered to be vital in an open architecture environment.

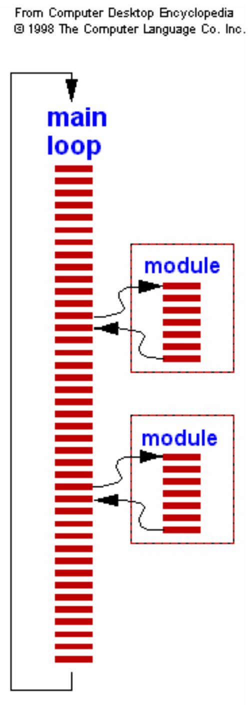

Figure 1. Modular Design Model

b. Reuse

Segments of code that provide defined functionality (command and control, sensor control, track identification etc.) which can be catalogued and reused over multiple platforms (AEGIS, SSDS etc.) provide greater flexibility in creation and maintenance of application software. The analogy one might use would be in the assembly of an automobile. The auto (system) needs multiple parts (components) which are broken down by functional capabilities (fuel system, brake system, cooling system etc.). When one desires to build the auto, they need only go to the parts store and purchase the required parts and assemble them together to create the finished product. The same holds true for software reuse: Libraries of components, or segments of code, are created and maintained so that they may be retrieved and used in the creation of new systems that require the specific functionality that the components provide. Generic and functionally-specific components can be mixed and matched without undermining the overall design of the system, nor impeding the overall functionality of the system. Through the partitioning of components along functional boundaries and reuse, systems can be designed more efficiently, thereby reducing lifecycle costs and development time. Though this attribute seems to be strictly technical, component reuse is determined through business case evaluation, programmatic decisions and technical feasibility, ensuring that the operators of a system have input into its development.

c. Scalability

Within an OA framework, scalability implies the ability of a system to accommodate new functionality and resources without major change or modification. The idea of increasing users, workload or amount of transactions without affecting the current operation of the system is a large part of an open architecture framework. Through adding computing components; upgrading current computing components; or providing a technology refresh of current computing components, new functional capabilities can be provided without disrupting current capabilities so that continuity of work can be achieved. This concept is imperative to the operational value of a system.

d. Portability

Portability speaks to the idea that applications can be easily moved from one hardware or software platform to another. Due to increasing and rapid advances in technology, it is imperative that application source code is able to transition between multiple operating systems, commercial hardware, networks and middleware. If an open architecture is to be adhered to, applications must have built in capabilities for seamlessly switching between a multitude of hardware and software platforms. Additionally, portability can be defined as the ability of the user to transition from one system to another similar system with minimal training. While user portability is not widely thought about, it does have implications in the operational context of a system. Table 1 provides a listing of possible strategies for implementing portability in an application.

Method	Definition	Usage	Benefits	Comments
Standards	Use of widely recognized standards (e.g. international) to ensure application portability	Basis for many systems	Many vendors and products OSJTF endorsed	Standards do change slowly, must be tracked
Widely used products	Use of commonly available non-standard products, e.g. MicroSoft	Widespread in practice, often business-based	Readily available products OSJTF 2nd choice	Vendor lock Market captive Must upgrade
Porting	Moving applications from one set of technology products to another (e.g. OS, M/W) by changing APIs within applications	Often used to move from non-standard basis to standards	Low or no cost if porting within standards family	Not all products exactly match standards
Virtual machine	Run-time interpreter of machine independent version of source code (e.g. Java byte code)	Widely used with popular Java language	Portable code	Not good for real-time apps
Wrappers	Software layer that hides a variety of products below and exports a common interface to applications	Used to hide non-standard products	Low cost within domain of use	Vendor lock Slows migration to standards
Emulation	Software layer that makes one type of computer appear to be another type by "emulating" the missing computer's instructions	May be used for legacy and obsolescent systems	Software does not have to change to new computer type	Overhead Architectural obsolescence
Model Driven Architecture	Use of highly abstracted modeling tools (e.g. UML) for design; source code generated automatically	Not yet widely used but holds great promise	Hides details May enable auto code generation	Still maturing

* Primarily addresses portability across operating system and middleware products; modern processors are largely (but not completely) abstracted by OS & M/W. Thus, portability at OS & M/W level supports processor & hardware independence.

Table 1. Application Portability Strategies (OACE Design Guidance 1.0, August 2004)

2. OA Benefits

A comparison of open systems and closed or proprietary systems is presented in Table 2.

Closed System Characteristics	Open System Characteristics
Use of closely held, private interfaces, languages, data formats and protocols (government or vendor unique standards)	Use of publicly available and widely used interfaces, languages, data formats and protocols
critical importance is given to unique design and implementation	critical importance is given to interfaces management and widely used conventions
less emphasis on modularity	heavy emphasis on modularity
vendor and technology dependency	vendor and technology independence
minimization of the number of implementations	minimization of the number of types of interfaces
difficult and more costly integration	easier and more cost effective integration
difficulty with portability, connectivity interoperability and scalability	high degree of portability, connectivity, interoperability, and scalability
use of sole-source vendor	use of multiple vendors
expansion and upgrading usually requires considerable time, money and effort	easier, quicker and less expensive expansion and upgrading
higher total ownership cost	lower total ownership cost
slower and more costly technology transfer	technology transfer is faster and less costly
components, interfaces, standards, and implementations are selected sequentially	components, interfaces, standards, and implementations are selected interactively
systems with shorter life expectancy	systems with longer life expectancy
use of individual company preferences to set and maintain specifications	use of group consensus process to maintain interface specifications
less adaptable to change in threats and technologies	more adaptable to evolving threats and technologies
focusing mostly on development cost and meeting present mission	focusing on total costs of ownership, sustainment, and growth
user as the producer of systems	user as the consumer of components
rigid and slow system of influence and control	real time and cybernetic system of influence and control
adversarial relationship with prime contractors/suppliers/vendors	Symbiotic relationship with prime contractors/suppliers/vendors
mostly confined to traditional suppliers	non-traditional suppliers can compete
simple conformance testing	very challenging conformance testing

Table 2. Open versus Closed systems (The Test and Evaluation Challenges of following an Open System Strategy" by Cyrus H. Azani)

An OA approach to systems development can produce a multitude of benefits that encompass a wide range of areas, from acquisitions to operations. A few of these benefits are discussed as they pertain to naval combat systems:

- Lower life cycle cost for weapon systems: Total cost of ownership will be decreased due to increased maintainability, interoperability and upgradeability.

- Better performing systems: The ability to rapidly upgrade hardware and software with the latest technology enables greater capabilities, efficiencies and interoperability.

- Improved interoperability for joint war fighting: The concept of software reuse and modularity facilitates interoperability between systems that use an open architecture framework.

- Closer cooperation between commercial and military electronics industries: Moving away from proprietary systems, where competition becomes obsolete enables a broader range of ideas and technological solutions to be presented. When systems are open, the collaborative efforts provide for a more functional and capable system.

In an operational environment, benefits of open architecture can be manifested in a multitude of ways. Of primary focus is the interoperability of systems. When systems are designed in a proprietary, or closed, manner they are not effectively integrated into current systems, nor are upgrades or insertion of new technology easily accomplished. Many times additional "middleware" must be used so that interoperability can be achieved (middleware, for this purpose, is software that connects two disparate and closed systems together through the use of defined interfaces). When systems use an OA approach, the interoperability problem can be rectified. The outcome for the operator could possibly be decreased training time required for the systems; decreased "touch time" on processes through automating what was normally a manual process; and increased efficiency through seamless integration of multiple systems. The interoperability of multiple applications enables systems to be more robust, which in turn, facilitates more capable systems.

Operators always want more capable and better performing systems. Using an OA approach to system development can make this a reality. Speaking on the status of legacy hardware for naval systems, Captain Thomas Strei, Deputy Director for Open Architecture, PEO IWS stated that "current systems are operating at 99% capacity in non-stressed environments" (Strei, 2003). Upgrades that would facilitate greater processing capacity, increased data sharing capabilities and communication are unable to be performed without completely overhauling the current systems. With an open architecture approach, hardware and software can be modularized, making upgrades more efficient and timely. Commercial-off-the-Shelf (COTS) technology and equipment is maximized to the fullest extent, thereby migrating away from proprietary hardware and software to a more robust architecture that takes advantage of commercial advances. This idea enables the most current technology to be integrated into the system, facilitating faster, more efficient systems at the disposal of the operators.

3. OA Limitations

While there are many benefits to the use of an OA approach, there are also some limitations that must be addressed. As risk analysis and mitigation are important factors when determining an architectural approach, limitations need to be discussed at the onset of any program.

Of main concern is the number of interfaces that may be brought about by an OA approach. The following is an excerpt from the Committee on the FORCEnet Implementation Strategy regarding systems engineering strategies for FORCEnet: "The number of unique interfaces that must be maintained needs to be carefully selected and kept to an absolute minimum, or evolution will be hindered by expensive and lengthy integration and testing. One way to do this is to require that systems must partition common functions in a common way" (Committee on the FORCEnet Implementation Strategy, 2005). Due to the inherent complexity and amount of systems within the Fleet, using an OA approach could eventually lead to problems with interface maintenance. As OA takes hold and becomes the standard for architectural design, the amount of interfaces will grow and expand to a point that could become unmanageable. Care must be taken to ensure this does not occur. As pointed out, the partitioning of functions in a common way is a mitigation technique, but this requires due diligence throughout the Navy, and very detailed requirements development to ensure that component functionality is partitioned in a manner that will facilitate reuse across multiple platforms. While this poses a technical and managerial limitation to OA, there are other factors that may contribute to the inability of an organization to transition to an OA framework.

While not an inherent technical limitation to open architecture, implementation of an OA framework can be troublesome. Transitioning legacy systems to ones that use an open architecture framework has the potential for huge up-front costs and reoccurring maintenance costs. In order to make the transition, new strategies in both training and technology must be developed so that expertise in the new architecture can be achieved. Investments in infrastructure upgrades to support the OA and a reevaluation of application software will be required, necessitating more costs in the near term. Middleware, software that acts as an interface between proprietary, legacy systems and OA systems, must be used in the transition, causing additional funding requirements. The need to support both the current proprietary systems and the new OA systems can become costly in both operational and maintenance environments. A transition period could last as long as 10 years, during which time both architectures must be supported and maintained in order to preserve operational capabilities. As the proprietary systems become obsolete, they will require specialized support until they reach the end of their lifecycle and are replaced.

C. DEPARTMENT OF THE NAVY OA TRANSITION

Realizing that the proprietary, legacy systems that comprise the majority of the systems within the Department of the Navy are limited in their processing power; difficult to upgrade and expand capabilities; and are not on the same technological level as their commercial counterparts, the DON has determined that an OA engineering framework is needed in its approach to systems development. To achieve this transition, the PEO IWS, OA Division was created as the responsible organization. From this organization came the Open Architecture Computing Environment (OACE) which is the “overall set of resources used in OA systems” (OACE Design Guide 1.0, 2004). The PEO IWS, OA has set about to implement the OACE and has provided a roadmap to realize this goal.

1. OACE Compliance Categories

The foundation for the OA migration strategy begins with determining compliance categories that will be used to identify approaches for systems to operate within an OA environment. Figure 2 outlines these categories.

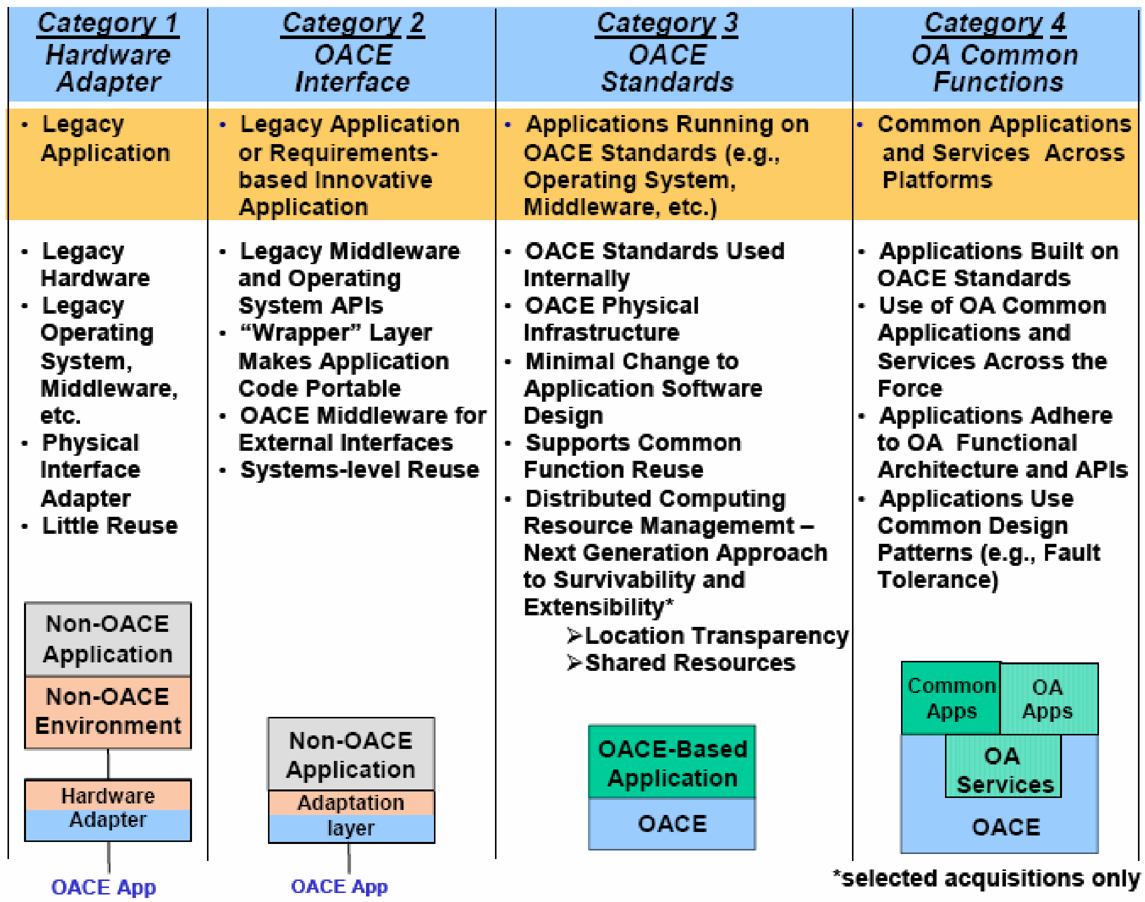

Figure 2. OACE Compliance Categories (OACE Tech and Stds 1.0, 2004)

Category 1 provides for hardware adapters for non-OACE compatible legacy systems. This is the lowest level approach and would be well suited for applications that are near their end of life and will not be maintained, or will not be transitioned into an OA framework due to operational requirements. Category 2 goes a step further and implements the concept of middleware. Legacy applications are isolated from OACE compliant systems through the application of OACE compliant middleware. This is the fist category were OACE compliance is addressed. Category 3 is one of two fully compliant categories (the other being Category 4) where OACE standards and interfaces are completely adhered to. Lastly, Category 4 provides all the attributes of Category 3, but it also ensures that common functions and services are applied. The concept of common functions and services facilitates reuse of the software across multiple platforms and systems, as software components are derived through functional divisions.

With a basic understanding of "where we are" a strategy to get to "where we want to be" can be generated.

2. Strategy

Operational responsibilities necessitate a phased approach to implementing an OA framework within the DON. Figure 3 outlines the phased approach to implementing OA with respect to the compliance categories.

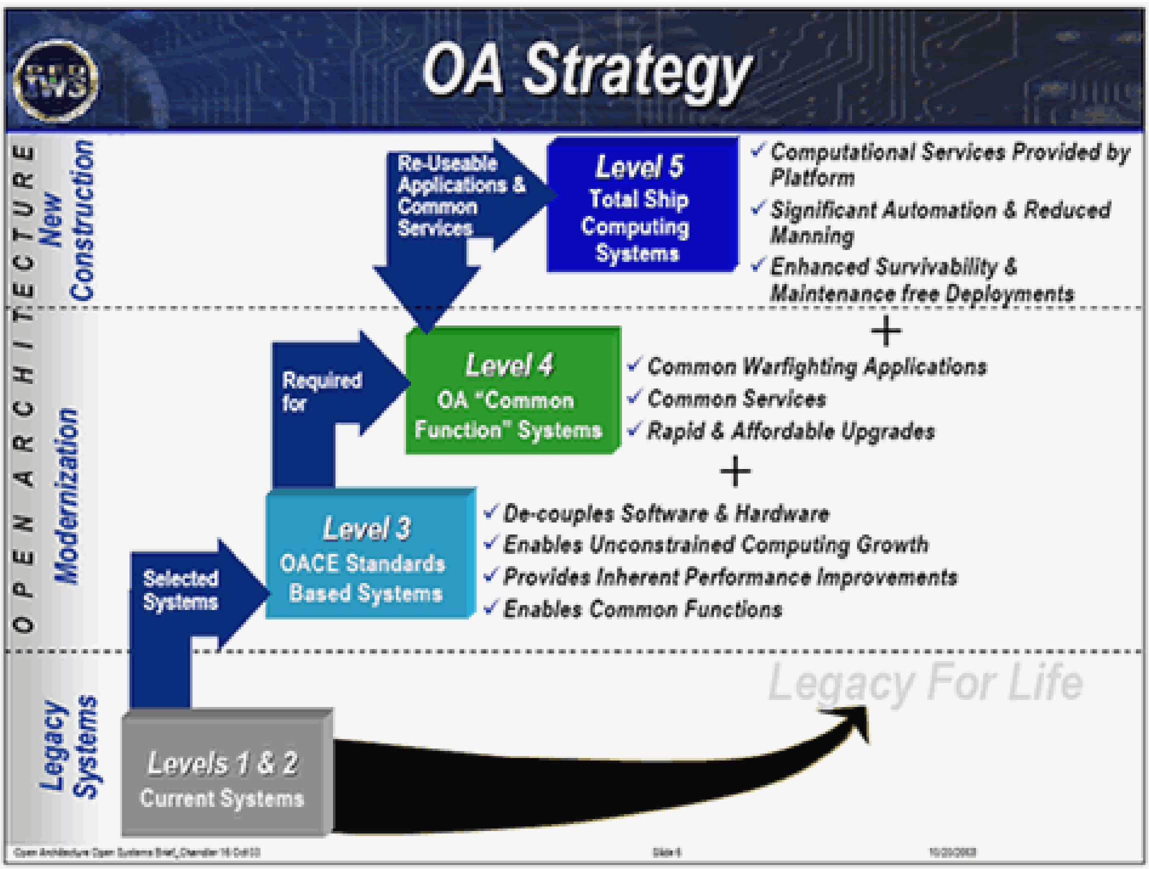

Figure 3. DON OA Strategy (slide presentation by Mike Rice, Deputy PM, OA and Mike Russell, Anteon Corp. for E-Gov Conference, 2004)

The transition from each level can be correlated to a phase within the OA Transformation Roadmap, presented in Figure 4. Each movement upwards in the level of compliance is directly tied to a schedule and phased transition so that operational capabilities are not affected. With each step the Navy gets closer to the ultimate goal of producing systems that "will be fully interoperable with all the systems which they must interface, without major modifications of existing components" (Rice and Russell, 2004).

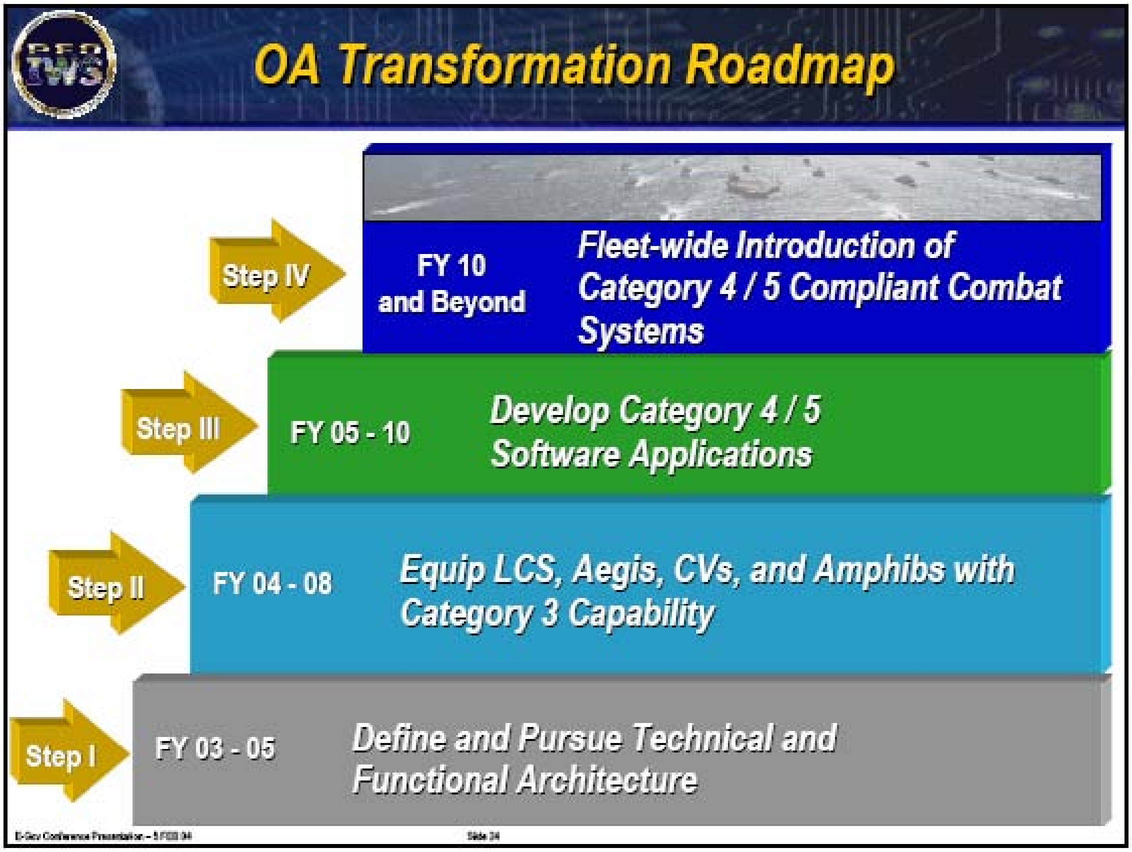

Figure 4. DON OA Transformation Roadmap (slide presentation by Mike Rice, Deputy PM, OA and Mike Russell, Anteon Corp. for E-Gov Conference, 2004)

III. THE KNOWLEDGE VALUE ADDED METHODOLOGY

A. MEASURING VALUE WITHIN THE DEPARTMENT OF THE NAVY (DON)

One of the greatest hurdles that face the Department of Defense is measuring the value associated with its information technology systems and the processes that function within, and in conjunction with, these systems. Webster's dictionary provides the definition of value as, "the monetary or relative worth, utility or importance of something," and seems to fit within the context of those systems that function in non-revenue generating environments such as the DON. In the commercial world, value can be measured through the revenue generated by an information technology system, or by the cost savings that the system may achieve. However, within the Federal Government (specifically the Department of the Navy) and, for that matter, any non-revenue generating entity, monetary revenue is not always an easily interpreted measurement of value.

With the introduction of the Information Technology Management Reform Act (ITMRA), better known as the Clinger-Cohen Act of 1996, the Federal Government was mandated to provide a measurement of performance of their information technology systems, and that measure would be determined by "how well the information technology supports the programs of the executive agency" (ITMRA). This was taken further by then Secretary of Defense Cohen to define a means of evaluation that will "utilize mission outcome based performance measurements as the cornerstone for information technology performance assessments" (Appendix K, Annual Defense Report, 1999). The foundation having been laid, the performance metrics, or measurements indicators are left to the discretion of the program manager.

Office of Management and Budget (OMB) Circular A-11 requires that an Exhibit 300 I.C. be submitted to OMB for any major IT initiative acquired after 2005. Table 3 is an example of a possible Exhibit 300 I.C. (example does not include "Baseline", "Planned Improvements to the Baseline" and "Actual Results" as it is only designed to illustrate possible measurements). The four "Measurement Area" entries are mandatory, while the "Measurement Category" and "Measurement Indicator" are left to the discretion of the program manager or agency. Indicators must be tailored to each specific system and must provide clearly defined and measurable outputs that are attributable to the "Measurement Category" and "Measurement Area". Quantitative versus qualitative indicators are the preferred measure so that a determination can be made as to how the IT initiative will support the strategic goals and objectives of the organization.

Fiscal Year	Measurement Area	Measurement Category	Measurement Indicator	Baseline	Planned Improvements to the Baseline	Actual Results
2005	Mission and Business Results	Planning and Resource Allocation	Degree to which agency migrates to its IT Enterprise Architecture			
2005	Customer Results	Timeliness & Responsive-ness	% of Enterprise Architecture requirements, guidance, and deliverables provided to agency EA staff on schedule			
2005	Processes and Activities	Financial	Cost avoidance attributable to consolidations identified in Target EA			
2005	Technology	Effectiveness	% of internal users who report using the EA management system as intended			

Table 3. Example Exhibit 300 I.C. (Performance Reference Model, Vol. II, 2003)

Historically, metrics have been associated with financial returns on investment, but as shown in table 3, the measurement indicators for a government IT system need to be tied to mission outcome, not the overall input to the system.

The Knowledge Value Added (KVA) methodology applies the idea that the inherent knowledge in a process is a viable determinant of the process' value. Through the application of the KVA methodology, knowledge within core processes of an organization can be measured and the resulting return on knowledge can be used to provide a means of evaluating multiple processes through common units of measurement. This methodology does not require that the common units be reflected in the form of monetary or financial value. The processes within the operational context of a CIC can, through KVA, all be described in common units of output, the resulting productivity ratio (ROK) can then be evaluated to determine where efficiencies may be obtained.

B. THE KVA SOLUTION

1. Knowledge Value-Added (KVA) Theory

Developed by Dr. Thomas Housel (Naval Postgraduate School) and Dr. Valery Kanevsky (Agilent Labs) over 15 years ago, KVA is a means to value the knowledge assets within an organization. Built upon complexity (measure of common unit of change) theory, the methodology asserts that core processes within an organization process inputs and add value to those inputs, changing the inputs into outputs through some application of change, thereby producing an output that has exhibited a transformation from the original input. The theory states that the difference (i.e., change) between the inputs from that of the outputs is the value provided by the organization's assets (i.e., people, processes or IT systems) which acted upon the inputs. In this manner, we can see that the knowledge within a process is proportional to the amount of change made to an input to produce the output. This knowledge value, measured in standard units of output, facilitates the analysis of multiple, differing processes throughout an organization, and empowers management to make more informed decisions concerning their core processes.

Knowledge embedded in core processes of an organization can now be evaluated and compared across the entire organization. KVA produces a common unit of knowledge that serves as a surrogate for units of output in a standard way (Housel and Bell, 2001), and in doing so, provides a decision support mechanism for those within the organization to make more informed decisions concerning the insertion of information technology into the processes. With a better understanding of where knowledge assets reside, a more in depth evaluation of an organization's processes can be achieved where efficiencies can be expanded upon and deficiencies can be rooted out and changed.

2. KVA Assumptions

With any methodology or framework there are certain assumptions that must be addressed so that a basic understanding can be agreed upon and the level of uncertainty can be mitigated. With KVA, the following assumptions apply:

1. There must be an input, a process that acts upon the input to produce an output.

2. The type of process (i.e., IT system, employees, procedures etc.) which acts upon the input is irrelevant to the measure of change.

3. Should the input equal the output, then there was no change, nor any value added from the process.

4. Value created by the process is relative to the change that the process applies to the input.

5. Change is measured by the amount of knowledge required to produce the change.

6. Accepting 4 and 5 above, value and knowledge are then related

7. Knowledge can be defined as the amount of time it takes an average learner to acquire the knowledge.

These assumptions are visually represented in Figure 5, below.

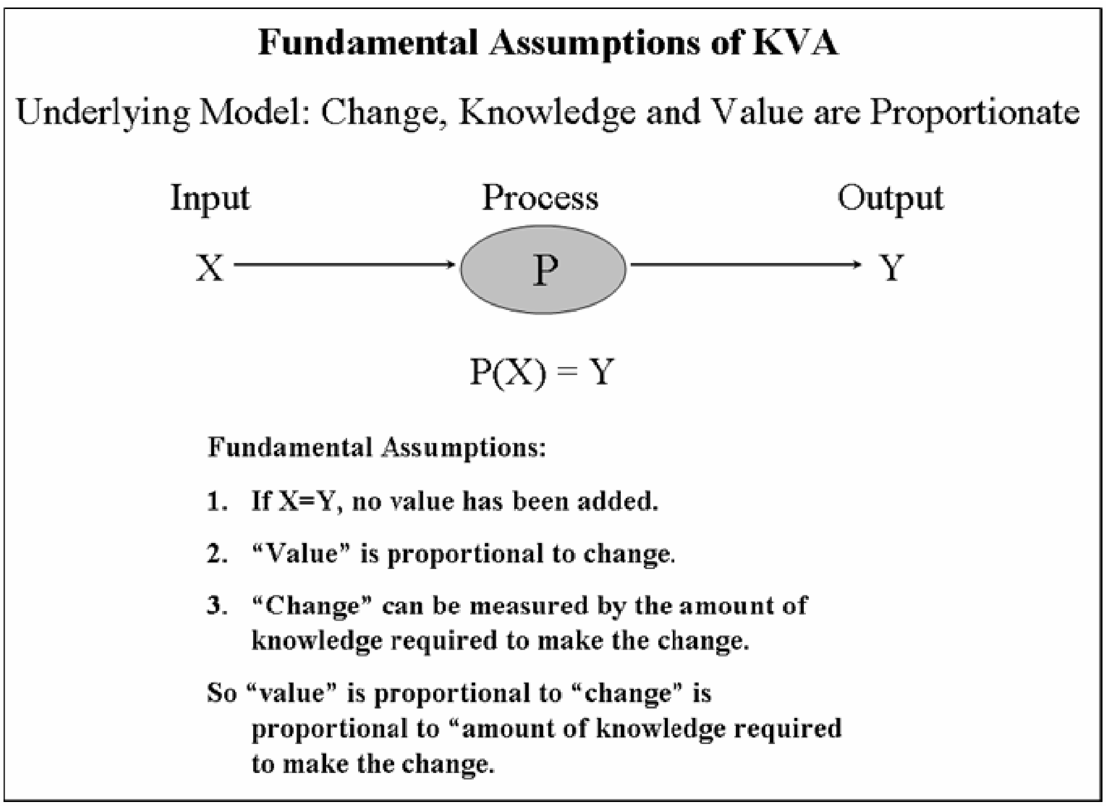

Figure 5. Assumptions of KVA (Housel and Bell, 2001)

3. KVA Approaches

The KVA methodology presents a very robust and dynamic framework that can use three different approaches for capturing the knowledge inherent in the core processes within an organization. While these approaches vary in application, neither is better or worse than the other, they simply present different collection means for deriving a result. It is important to note that once an approach is decided upon, it should be applied consistently throughout the organization. Processes cannot be correctly evaluated if they use differing approaches to determine their value. While the learning time approach is applicable to this thesis, each of the three methods is described in Table 4.

Steps	Learning Time	Process Description	Binary Query Method
1	Identify core process and its sub processes.		
2	Establish common units and level of complexity to measure learning time.	Describe the products in terms of the instructions required to reproduce them and select unit of process description.	Create a set of binary yes or no questions such that all possible outputs are represented as a sequence of yes or no answers.
3	Calculate learning time to execute each sub process.	Calculate number of process description words, pages in manual, and lines of computer code pertaining to each sub process.	Calculate length of sequence of yes or no answers for each sub process.
4	Designate sampling time period long enough to capture a representative sample of the core processes final product or service output.		
5	Multiply the learning time for each sub process by the number of times the sub process executes during the sample period.	Multiply the number of process words used to describe each sub process by the number of times the sub process executes during sample period.	Multiply the length of the yes or no string for each sub process by the number of times the sub process executes during sample period.
6	Calculate cost to execute knowledge (learning time and process instructions) to determine process costs.		
7	Calculate ROK and ROP and interpret the results.		

Table 4. Three Approaches to KVA (Housel and Bell, 2001)

a. Learning Time

This approach uses a measurement based on the time it would take an average person to learn the process in question. The measurements must be in common units of time (i.e., hours, days, weeks etc.) and should be verifiably reliable. To obtain the learning time measurements, all time required to learn the process must be indicated. This may include training at a formal school, on-the-job-training (OJT), distance education and any other source of training that would be relevant to the generation of an output by means of the process indicated. Generally SME's, training manuals and standard operating procedures can provide a means for determining the actual learning time, although this type of information gathering can be prone to subjectivity. To avoid this and mitigate the risk of obtaining erroneous data, a correlation among two estimates can be calculated to ensure the most reliable and accurate data has been provided.

Correlation can be achieved by obtaining an ordinal ranking based on the difficulty to learn each sub process within the organization. SME's are asked to rank order each sub process in order of difficulty to learn. This ranking is then correlated against the actual learning time data that was provided. Should the two provide a correlation of 80% or greater, the data can be considered to be reliable. A correlation below 80% assumes a discrepancy in either the rank order or the actual amount of learning time required for each process. This can occur when SME's do not completely understand the problem domain and provide learning time estimates that are faulty. Restructuring the learning time question or requesting a revalidation will normally be required.

b. Process Description

This approach measures the number of instructions needed to reproduce the outputs produced. Using the process description approach enables the KVA methodology to achieve a higher level of detail in the process description than does the learning time approach. It requires a more detailed and analytical description of each process and the amount of instructions needed to produce each output. The process instructions are calibrated in terms of their complexity.

c. Binary Query

Utilizing the binary query approach requires the creation of a set of binary yes/no questions such that all possible outputs are represented as sequences of yes/no answers (i.e., bits). These sequences can then be calculated and value can be attributed to the outcome.

C. RETURN ON KNOWLEDGE (ROK)

Return on Knowledge (ROK) is the ratio of revenue allocated to each core area compared to its corresponding expenses (Housel and Bell, 2001). The essence of KVA is found in the ROK ratio that the methodology provides. As stated earlier, knowledge is a surrogate for common unit outputs, so ROK provides a means for determining a knowledge value to cost ratio for all processes within an organization. Proper application and analysis of ROK can provide an organization with a better understanding of the productivity of its knowledge assets, where they are located and how efficiently they are being applied throughout the organization. For non-revenue generating organizations this can be a force multiplier for validating processes and IT systems.

IV. PROOF OF CONCEPT

A. INTRODUCTION

Program Executive Office, Integrated Warfare Systems (PEO IWS), Open Architecture Division is charged with implementing the Navy's OA plans, policies and initiatives. One of these initiatives is the implementation of an open architecture approach to developing a situational awareness (SA) system for the DD(X) project. To accomplish this, PEO IWS has looked at both the AEGIS and SSDS platforms to determine specific elements of each track management system that could possibly be reengineered using open architecture approach for placement into the new DD(X) program. In doing this, metrics must be looked at to determine the best modules that could be candidates for open architecture.

This proof of concept will take information from subject matter experts from both the Surface Warfare Fleet and from training commands at Dahlgren (AEGIS) and Wallops Island (SSDS). The process information garnered from these SME's will then be aggregated to provide an average for each process (multiple sources provide multiple figures, so an average will be calculated to ensure a more accurate result is achieved) using the KVA methodology. This analysis is the "As Is" baseline. The resulting ROK's will then by analyzed to determine if information technology, specifically with relation to systems built using an open architecture approach, could be inserted to enhance the operational capabilities of a Combat Information Center (CIC) aboard a naval vessel. Lastly, a Real Options analysis can be conducted on possible ROK values generated from the "To Be" model of the SA system, thereby providing PEO IWS with an idea of specific processes within the SA system that could be reengineered with an open architecture approach to provide the greatest value to the operational fleet.

B. HYPOTHESIS

Measures of effectiveness (MOE) for open architecture in an operational environment can be derived through the application of the Knowledge Value Added Methodology. These MOE metrics can then be used to support decisions for acquisition, procurement, development and integration of software components by generating a return on knowledge for each core process within the situational awareness arena.

C. ANALYSIS AND DATA COLLECTION

1. Track Management in the Combat Information Center (CIC)

Each platform (AEGIS and SSDS), and for that matter, each ship, has different procedures and policies regarding the situational awareness or track management functions within the CIC. While these functions may vary, the cores of the processes that make up the system are basically the same and have been validated by both Fleet personnel and personnel at the formal schools. The current track management process has a mixture of automation and manual processes involved, and while there are variances as to the amount of each, an aggregated amount will be used so that an average output can be assumed for estimation purposes.

Track management within a CIC is a complex process, involving multiple sub processes and multiple individuals. Outputs from one sub process may, or may not, have a bearing on another sub process within the overall situational awareness process. This ability of each sub process to possibly be a stand-alone process or be integrated into the bigger SA system provides for a robust and highly capable system, but also makes an analysis of the system very complicated and challenging.

2. Data Collection Challenge

Due to the complex nature of the track management system in the CIC, collecting appropriate data that can be analyzed through the KVA methodology was challenging. Outputs, learning time and touch time of many sub processes that make up the entire system are not generally collected or retained. Within the Navy, training times and required on-the-job-training (OJT) are targeted at specific watch stations rather than specific processes, which is what KVA requires. Due to this, data derived for the purpose of this analysis was extracted through conversations with SME's and reviewing of Personal Qualification Standards (PQS). Multiple SME's were contacted so that an aggregated sample could be achieved.

D. DEFINING THE TRACK MANAGEMNT PROCESS

1. CIC Overview

With respect to this thesis, the following watch stations were identified as having a direct impact on the track management process within a CIC. These watch stations, while sometimes being associated with different names, were consistent on both AEGIS and SSDS platforms. Additionally, though the watch stations have specific tasks and responsibilities, in an actual CIC all personnel listed can be actively involved in any, or all, aspects of track management (correlation, identification, tracking, and relaying). While there will be variances from ship to ship; Figure 6 is a generalized organizational chart of the personnel within a CIC that are actively involved with track management.

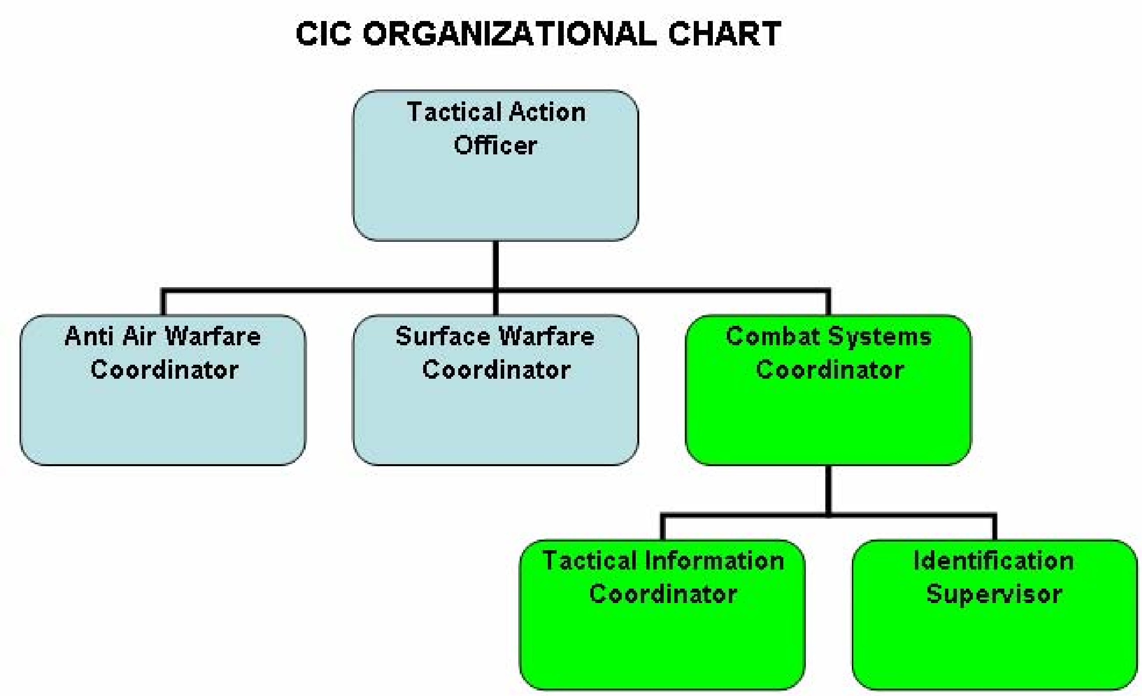

Figure 6. CIC Organizational Chart

2. CIC Watch Stander Descriptions

a. Tactical Action Officer (TAO)

The Tactical Action Officer has overall responsibility for actions within the CIC. The TAO leads the CIC watch team and coordinates the track management functions within the CIC. As the senior watch station within the CIC, the TAO is responsible for most track management decisions made within the CIC. The TAO watch station is predominantly filled by a field grade officer. Additional duties that may be accomplished by the TAO outside of the track management domain are not applicable to this thesis.

b. Anti-Air Warfare Coordinator (AAWC)

The Anti-Air Warfare Coordinator is responsible for the overall air picture within the CIC. A majority of the time, the AAWC will be the second senior officer in the CIC. The AAWC directs a team of operators in the detection, identification and dissemination of aircraft tracks within the ship's airspace. The AAWC will control movement of friendly aircraft assigned to the ship, attend intelligence briefings and maintain a general awareness of the air picture during all phases of CIC operations. While charged with the overall status of the air picture, the AAWC will delegate many of the specific track management tasks to subordinates so as to keep track of the overall air picture. The AAWC watch station is predominantly filled by a junior officer. Additional duties that may be accomplished by the AAWC outside of the track management domain are not applicable to this thesis.

c. Surface Warfare Coordinator (SUWC)

The Surface Warfare Coordinator is responsible for the overall surface picture within the CIC. The SUWC directs a team of operators in the detection, identification and dissemination of surface tracks within the ship's airspace. The SUWC will attend intelligence briefings and maintain a general awareness of the surface picture during all phases of CIC operations. While charged with the overall status of the surface picture, the SUWC will delegate many of the specific track management tasks to subordinates so as to keep track of the overall surface picture. The SUWC watch station is predominantly filled by a junior officer. The Additional duties that may be accomplished by the SUWC outside of the track management domain are not applicable to this thesis.

d. Combat Systems Coordinator (CSC)

Usually the senior ranking enlisted in the CIC, the Combat Systems Coordinator is charged with monitoring and initiating troubleshooting procedures for communications systems, Tactical Digital Information Link (TADIL) Links and the Identify Friend or Foe (IFF) system. The CSC is directly responsible for identification processes within the CIC, to include AEGIS ID doctrine and track management operator performance. The CSC provides support to all operators within the CIC in the management of air and surface tracking, identifying and relaying. Additional duties that may be accomplished by the CSC outside of the track management domain are not applicable to this thesis.

e. Tactical Information Coordinator (TIC)

The Tactical Information Coordinator operates and maintains the TADIL A (Link 11) and TADIL J (Link 16) between friendly air and surface craft within the area of operations. The inherent importance of the Link picture, the TIC is primarily focused on ensuring a clear, coherent picture is presented over the Links. The TIC is responsible for identifying and quickly resolving any correlation issues ("same contact, multiple tracks"). The TIC watch station is predominantly filled by a junior enlisted. Additional duties that may be accomplished by the TIC outside of the track management domain are not applicable to this thesis.

f. Identification Supervisor (IDS)

The Identification Supervisor is charged with the overall identification process within the CIC. The IDS will be responsible for IFF challenges, query and/or warning procedures directed at suspect contacts and inputting of information into the CIC track database (AEGIS Command and Display system). The IDS will monitor all tracks and ensure timely and accurate identification can be generated so that decisions can be made as to the intent of the contact. The IDS is primarily focused on the air picture (due to the immanent danger of air contacts with relation to surface contacts), but does support the surface picture as well. The IDS watch station is predominantly filled by a junior enlisted. Additional duties that may be accomplished by the IDS outside of the track management domain are not applicable to this thesis.

3. Defined Track Management Sub Processes

The process of track management within a CIC is a very complex and sophisticated process involving multiple watch stations and technological systems. In order to analyze the process with the KVA methodology it was necessary to decompose the track management process into individual sub processes. This decomposition enables a more diverse analysis of each functional area within the track management process. The core processes that make up track management are provided below in Figure 7. These core sub processes were derived from correspondence with multiple Subject

Matter Experts in both the AEGIS and SSDS communities. While each of the sub processes may differ from ship to ship, the SME's concluded that these 4 sub processes reflected the procedures that are conducted within a CIC for track management. These sub processes were further decomposed in order to evaluate the specific functions associated with each. Again, SME's were consulted and the basic understanding was that the 17 functional areas were at a sufficient level of decomposition for this thesis. While the SME's said there is no definitive sequential order in which the steps take place, the figure provides a possible sequence that could occur so as to provide a visual representation for the reader.

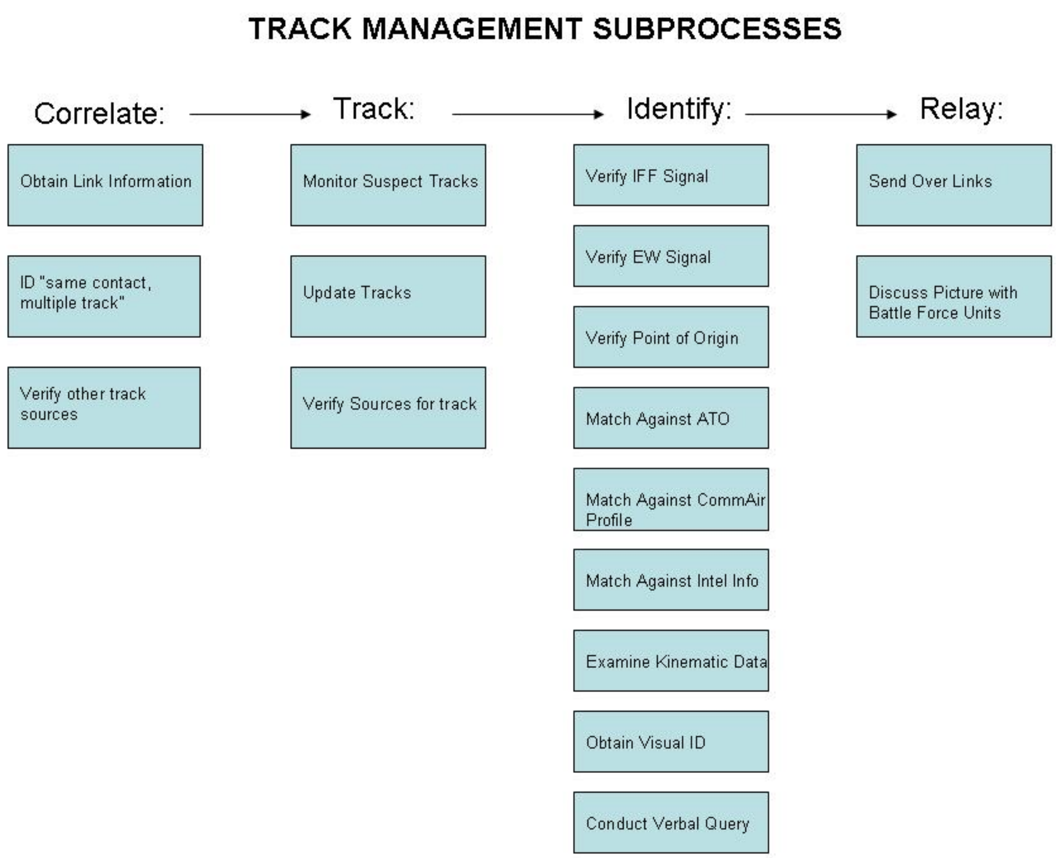

Figure 7. Track Management Sub Processes

Each of these sub processes and associated functions are conducted throughout the track management process. While some of the sub processes are not always conducted, the listing provides an aggregated decomposition that can be generalized for both the AEGIS and SSDS platforms, and each associated ship within those platforms. Each sub process is further defined below so that each can be understood in the context of this thesis.

a. Correlate

For the purpose of this thesis, correlate will be defined as the ability to combine target detections from individual radars, identification friend or foe (IFF) system and any additional electronic support measures systems that may be available to obtain a single, composite track that can be used to enhance the common operational picture within the CIC. This sub process is further broken into more specific functions below.

1. OBTAIN LINK INFORMATION: Tactical Digital Information Link (TADIL) Links A and J are the primary means by which elements within a battle group can exchange information about their individual air and surface pictures. The data passed provides each element with an updated common operational picture so as to maintain a real-time situational awareness of the battle force area of operations. TADIL A, commonly referred to as Link 11, is the older of the two, and is found on all platforms. TADIL A requires a Net Control Station (NCS) to manage the network and facilitate controlled communications where elements will transmit data to the NCS, and only once all elements have relayed their data will the NCS provide a consolidated picture to the entire battle force. TADIL J, commonly referred to as Link 16, is the newer system and provides for higher data transfer rates, resistance to jamming and the ability for multiple elements to transmit data simultaneously, without the use of a NCS. Some elements within the Fleet still do not possess the Link 16 capability. The process of obtaining, understanding, managing and utilizing the information from the Links is the crux of this sub process. A diagram of the TADIL J/Link 16 architecture is provided in Figure 8 below. The process is highly automated, with little operator input.

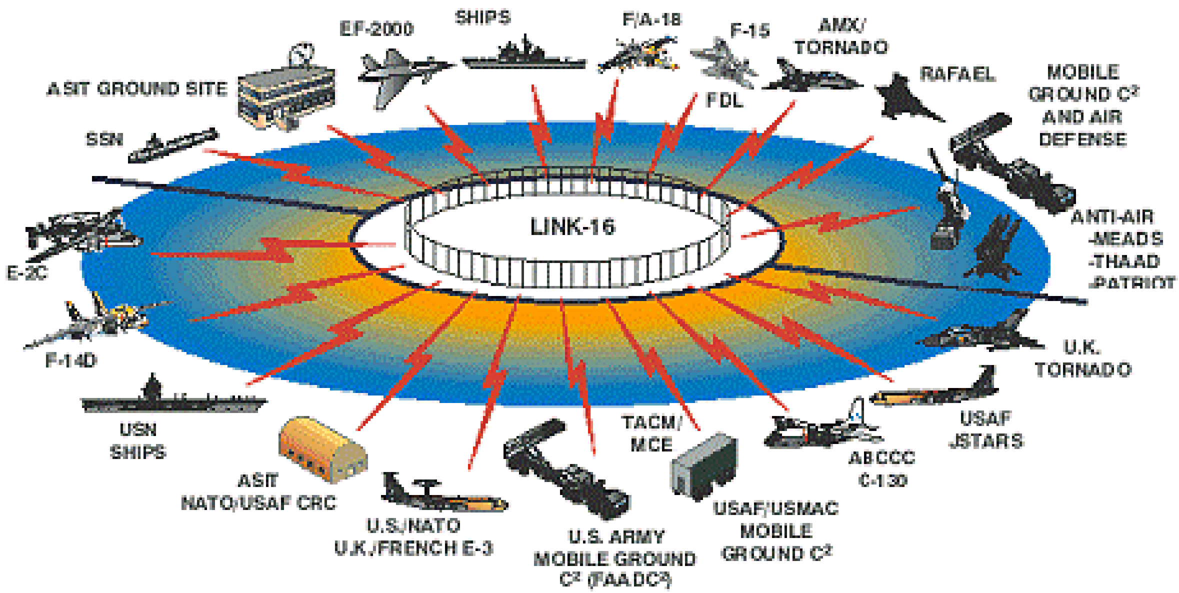

Figure 8. Link 16 architecture

2. IDENTIFY "SAME CONTACT, MULTIPLE TRACKS": Many times the AEGIS and SSDS platforms will identify the same contact with multiple tracks on the operator consoles. This anomaly must be corrected so that the operational picture can be clearly portrayed to the battle force. The process of identifying when there are multiple tracks for the same contact, and then correcting this error so that a single track is promulgated to the Fleet. This is currently a manual process that requires the operator to understand the anomaly and have the requisite knowledge to identify when it is occurring and the ability to correct the duplication.

3. VERIFY OTHER SOURCES FOR TRACK: Operators must be able to validate any and all sources for a given track. This will sometimes require verbal communications with adjacent elements in the battle force, querying system resources and understanding the multiple sensor nodes that are available at any given time and area of operations. Should a track come from a non organic asset of the ship, the operator must be able to contact the remote source and confirm the information that was provided for the given track.

b. Track

Track is the process by which a detected track is monitored and managed. This involves both operator and system functions and procedures. Visually monitoring a track and updating its status into multiple systems, as required, fall into the purview of this process.

1. MONITOR SUSPECT TRACKS: Once a track has been detected it has the ability to be monitored. Suspect tracks are those that have not been identified or have been identified as "hostile" or "unknown". These tracks pose a possible threat to the Fleet and must be monitored until they are identified as "friendly" or have been determined by competent authority as not to be of significant threat to the Fleet. This is still a highly manual process, although both systems can be programmed to monitor these tracks more closely.

2. UPDATE TRACK: Once a track has been detected and is in the process of being monitored, it may routinely need to be updated, both in the ship's organic systems and in any other systems that may require track integration. An update to a current track can consist of any myriad of information that is applicable to the track and can be performed at any time. An update is currently a manual process whereby an operator inputs information into the system as it becomes available. While updates can be performed by any operator, there is normally one individual assigned so as to provide continuity and coordination of effort.

3. UPDATE GLOBAL COMMAND AND CONTROL SYSTEM – MARITIME (GCCS-M): The Global Command and Control System enhances the operational commander's war fighting capability and aids in the decision-making process by receiving, retrieving, and displaying information relative to the current tactical situation. GCCS-M receives, processes, displays, and manages data on the readiness of neutral, friendly, and hostile forces in order to execute the full range of Navy missions (e.g., strategic deterrence, sea control, power projection, etc.) in near-real-time via external communication channels, local area networks (LANs) and direct interfaces with other systems (www.fas.org). The GCCS-M is updated both manually and automatically. The system uses Link 11 for connectivity, but has the ability to use Link 16 in certain instances. Tracks are automatically populated in GCCS-M via Link 11, but

deletions from the system require manual intervention. Due to the fact that this is a planning tool which provides non-real time track data, there is little emphasis within a CIC to update and monitor GCCS-M. A problem exists when staff planners, usually at the flag officer level, rely on inaccurate track data that has not been monitored, and subsequently updated, by operators within the CIC.

c. Identification

The identification sub process provides the greatest decomposition of the track management process. This sub process involves a multitude of functions that encompass the identification of detected tracks. The processes involved in identification are both manual and technology driven, and are the crux of the track management process. The ability to correctly identify a track in a timely and efficient manner is, quite possibly, the most important aspect within the track management process, which is why it was given so much attention.

1. VERIFY IDENTIFICATION FRIEND OR FOE (IFF) SIGNAL: The Identification Friend or Foe system is used for providing quick and accurate recognition of friendly aircraft and ships. Each friendly military aircraft/ship has a specific IFF code associated with it. Additionally, certain IFF codes are used by commercial aircraft internationally to provide a means of identification in support of the air traffic control tower missions. The unique codes and their functions are detailed below in Table 5.

IFF MODE	DESCRIPTION
Mode 1	Nonsecure, low cost method used by ships to track aircraft and other ships. Military application for determination of type of aircraft or mission
Mode 2	Military application for determination of aircraft ID number. Additionally used by aircraft to make carrier controlled approaches to ships during inclement weather.
Mode 3/A	Standard system also used by commercial aircraft to relay their position to ground controllers throughout the world for air traffic control (ATC). Commercially known as Mode A.
Mode 4	Secure encrypted IFF. Military uses to determine whether a contact is a friend or foe.
Mode C	Provides a three dimensional altitude response.

Table 5. Identification Friend or Foe Categories

IFF interrogation is almost completely automated. The system interrogates the contact through electronic signals, which the contact will provide an appropriate response, depending on which IFF mode it is utilizing. Operators only need to monitor this process and correct any anomaly's they may see.

2. VERIFY ELECTRONIC WARFARE (EW) EMISSIONS: Each aircraft type gives off an electronic signature that is specific to the type of aircraft. This signature can be collected and interpreted against known signatures. This process is substantially automated in the collection of information, but due to its processor requirements, the notification is not automatic as it would crash the current system. The procedure is for the cryptographic technician to verbally send a report to the CIC outlining the information gained from the emissions of the aircraft.

3. VERIFY POINT OF ORIGIN: Manual in nature, this is the process whereby an operator will try to determine the point of origin of a contact. This involves knowledge of the contacts kinematics information and verification of additional system resources (IFF, EW, Air Tasking Order etc.).

4. MATCH AGAINST AIR TASKING ORDER (ATO): The ATO is distributed on a daily basis via GCCS-M. A hard-copy printout will be provided to CIC personnel, which will be used to determine if a contact, based on time, kinematics, IFF and EW data could be a friendly aircraft depicted in the daily ATO. This is a currently a completely manual process.

5. MATCH AGAINST COMMERCIAL AIR (CommAir) PROFILE: Commercial air traffic use specific lanes and corridors in their flight patterns. These lanes and corridors are circulated and well known. Additionally, commercial aircraft have flight profiles (speed, altitude, emissions etc.) that are specific to the civil and commercial industry. The process of matching specific kinematics, IFF and EW information to that of known commercial profiles can be done almost completely through automation, with minimal monitoring for questionable contacts that may not trip a CommAir profile doctrine.

6. MATCH AGAINST INTELLIGENCE INFORMATION: Intelligence briefs are provided on a daily basis. These briefs provide the most current information as to the operational situation, friendly and enemy forces disposition and any additional updates as may be relevant to the Fleet. At a minimum, the TAO, AAWC and SUWC will attend these briefs. The process of applying the intelligence provided at the daily briefs in an attempt to identify a contact is completely manual.

7. EXAMINE KINEMATICS DATA: Kinematics data are attributes specific to a given contact. They may include, but are not limited to, bearing, speed and altitude. This information is provided by the system, but the operator must understand it in context and make decisions based on the information provided and known criteria. This process can be automated through ID doctrine, but more often than not, it is conducted by an operator.

8. OBTAIN VISUAL IDENTIFICATION: When available, either a friendly aircraft or a lookout on the deck can provide a visual identification of a contact. This process is conducted by an operator in the CIC verbally requesting one of the aforementioned elements to conduct a visual scan of the contact, if possible.

9. CONDUCT VERBAL QUERY: A completely manual process whereby an operator in the CIC, following the procedures of the ship, will

attempt to contact the unknown track via radio communications. The first attempt will most often be through an encrypted path, but if that fails, an unencrypted channel will be used to gain voice communications. Due to the fact that commercial aircraft do not have access to encryption, this process sequence can be altered (unencrypted radio communications before encrypted radio communications) should the operator believe the contact is a commercial aircraft versus a friendly military aircraft.

d. Relay

Once a contact has been identified, it is usually disseminated throughout the battle force. This process is conducted in a controlled manner so as not to publish erroneous track information and muddle the operational picture and situational awareness of the battle force.

1. SEND OVER THE LINKS: Once a contact has been identified, the process of providing the information via Link 11 or Link 16 is conducted. The operator will determine if enough information is provided for the contact to be given a "friendly" or "hostile" identity. If not enough information is provided, the operator may determine to send the contact out as an "unknown" and request additional support in identification from other sources within the battle group.

2. DISCUSS PICTURE WITH BATTLE FORCE UNITS: The entire track management process, as presented so far, is not sufficient to provide a completely accurate situational awareness of the operational picture. Different platforms have differing assets at their disposal or allied vessels may not possess the capability to tie into the network, so it is beneficial to conduct periodic discussions with the force elements to ensure a common operational picture is obtained. This is a manual process whereby an operator verbally communicates with other elements within the battle force.

E. "AS IS" KVA ANALYSIS

An analysis of each watch station within the track management process and the associated sub processes is provided for both the AEGIS and SSDS platforms in the following tables. The information provided for each analysis was produced through discussions, video teleconferences and phone conversations with SME's. Each category for the KVA analysis is defined below.

1. Number of Personnel

The "Number of Personnel" category represents the number of sailors and officers which are involved in the specific sub process. For purposes of this research, the column will reflect (1) due to the fact that each individual watch station is delineated and provided its own individual analysis. Were processes not broken down by watch stations, the number for this column would reflect the total amount of sailors and officers required to complete the given process.

2. Actions per Hour

The "Actions per Hour" reflects the number of times each sub process is executed by the specified watch stander. The actions are predicated on the amount of contacts, both air and surface, which are encountered during a typical hour within the CIC. Each contact must be acted upon, hence the rationale for "actions" versus "contacts" per hour. The values were obtained through querying subject matter experts, from both training and operational commands, as to what their experience has been with each sub process. Each SME provided an estimate, and these estimates were then aggregated to determine the average amount of actions per hour. Basic assumptions for this category were:

- Estimates were to be determined based on a typical, six month deployment
- The number of contacts were determined based on an average of both open ocean transit and operations in the littorals

3. Actual Work Time (AWT)

Each time a sub process is acted upon (as depicted in the "Actions per Hour" category) there is a specific amount of time that is required to accomplish the action. The "AWT" category captures this data in hourly units. While each of the actions only requires a few seconds, the category captures the data in hours in order to maintain continuity of units of time throughout the analysis.

4. Total Work Time

Each of the sub processes are acted upon multiple times during a given hour of operations. The "Total Work Time" category represents the total amount of time that each individual sub process is acted upon within an hour. This category is derived by multiplying the "AWT" and "Actions per Hour" categories together. The analysis is given in hourly units, so when "Total Work Time" for each of the sub processes are added together for each of the watch stations, the total aggregate should remain below 1.0. If the total was to exceed 1.0, we would know our calculations, or estimates, are incorrect as there is only 1.0 hours for all the given sub processes to occur. Given this, if the total was to equal 1.0, it would mean that for any given hour, 100% of the watch station's time is devoted to the sub processes depicted in the analysis.

5. Actual Learning Time (ALT)

The "Actual Learning Time" category is the focal point of the analysis. It provides the total amount of time that is required to learn the given sub process. Learning time can be an aggregate of formal schools, distance learning, OJT or any other training experience that could fall within the local command definition of "learning". For the purposes of this analysis, ALT is comprised of formal school training and OJT provided aboard ship. To ensure that all estimates from SME's were consistent, a standard baseline needed to be provided. The basic assumptions to achieve this baseline are provided below:

a. Officer-SSDS

The baseline for each officer was an individual that had completed initial officer training, but had no prior experience with the SSDS platform. Additionally, it was necessary to determine the formal schools that would be represented by this category. While each school's duration is considerably longer than the hours represented in the "ALT" category, estimates were determined based on the aggregated amount of time that was devoted to teaching the given sub process from each school:

- SSDS Basic Operator Course of Instruction
- SSDS Advanced Operator Course of Instruction
- SSDS Warfare Operator Course of Instruction

b. Officer-AEGIS

The baseline for each officer was an individual that had completed officer training, but had no prior experience with the AEGIS platform. Additionally, it was necessary to determine the formal schools that would be represented by this category. While each school's duration is considerably longer than the hours represented in the

"ALT" category, estimates were determined based on the aggregated amount of time that was devoted to teaching the given sub process from each school:

- AEGIS Training Course
- SWOS TAO School
- TAO Simulator Training

c. Enlisted-SSDS

The baseline for each sailor was an individual that had completed boot camp, but had no prior experience with the SSDS platform. Additionally, it was necessary to determine the formal schools that would be represented by this category. While each school's duration is considerably longer than the hours represented in the "ALT" category, estimates were determined based on the aggregated amount of time that was devoted to teaching the given sub process from each school:

- OS "A" School
- SSDS Basic Operator Course of Instruction
- SSDS Advanced Operator Course of Instruction
- SSDS Warfare Operator Course of Instruction (E5 and above)

d. Enlisted-AEGIS

The baseline for each sailor was an individual that had completed boot camp, but had no prior experience with the AEGIS platform. Additionally, it was necessary to determine the formal schools that would be represented by this category. While each school's duration is considerably longer than the hours represented in the "ALT" category, estimates were determined based on the aggregated amount of time that was devoted to teaching the given sub process from each school:

- OS "A" School
- AEGIS Console Operator Course

6. Rank Order (NLT)

An ordinal ranking of the sub processes provides a means to ensure the "ALT" estimates are reliable and as accurate as possible. By allowing the SME's to rank order each of the sub processes (1 being the least complex) outside the context of units of time, a mathematical correlation can be calculated between the "Rank Order (NLT)" and "ALT" categories. If a correlation of .80 or higher is achieved, the "ALT" numbers can be considered an accurate reflection of the sub processes complexity. Should the correlation result in a number below .80, "ALT" estimates should be closely scrutinized and possibly reevaluated after providing a better explanation of the "ALT" components to the SME's. It is possible to achieve a 100% correlation between rank ordered ordinal numbers and ration numbers (ALT) due to the mathematical properties of the two scales.

7. Percent Information Technology (%IT)

Each sub process is represented by a percentage between 0 and 100. This number is an estimate for the percentage of automation for each sub process. This category captures the knowledge that is embedded within the IT so that it can be accounted for in calculations in a way that is consistent with the human learning time estimates. Automation is defined as the amount of the sub process that is performed by information technology systems, and does not require the actions of an operator. If the category has 100%, this would indicate that the sub process is completely automated and does not require a watch stander to accomplish any portion of the task. If the category is 0%, there is no automation and the watch stander completes the entire sub process manually. Numbers that fall between the extremes are estimates based on SME observations and experience.

8. Total Learning Time (TLT)

This category is determined by dividing the "Actual Learning Time" by the "Percent Information Technology" category. The actual formula is ALT/(1-%IT). This calculation provides a total time required to learn the sub process, to include that learning time which is resident within the IT system. For instance: If it takes 2 hours to learn a system that is 50% automated, then the total learning time for that system (to include the learning time that is embedded in the system itself) would be 4 hours.

9. Numerator

The "Numerator" category describes the "percentage of the revenue or sales dollar allocated to the amount of knowledge required to obtain the outputs of a given process in proportion to the total amount of knowledge required to generate the corporation's salable outputs" (Housel and Bell, 2001). The revenue surrogate allocated to the amount of knowledge, for purposes of this research, is the amount of knowledge that is resident in the sub process. To calculate this category, the "Number of Personnel", "Actions per Hour", and "Total Learning Time" categories are multiplied together, providing the knowledge revenue surrogate for each sub process.

10. Denominator

This category denotes the cost associated with producing the output of the sub process. It is determined through multiplying the "Number of Personnel", "Actions per Hour" and "Actual Work Time" categories. This calculation provides the cost associated with the sub process.

11. Return on Knowledge (ROK)

With every sub process, there is a cost and value (or revenue) associated with generating an output. While these values and costs are captured in the "Numerator" and "Denominator" categories there needs to be a way to quantify the knowledge embedded within an IT system. ROK is the ratio between the "Numerator" and "Denominator" categories which is used to determine the value added by knowledge assets within a given process. The ratio provides a representation as to how well the knowledge assets in an organization are performing based upon the value and cost that each provides. ROK's can be compared within a process to help determine if knowledge assets are being used in an efficient manner; if automation could be inserted to improve process performance; and if processes should be changed to promote efficiencies. While ROK is a valuable tool, a low ROK does not automatically assume a process is inefficient or in need of automation, but rather is an indicator that the process may need further analysis to determine if it is using its knowledge assets in a productive manner.

12. "As Is" Process Data

Each of the processes, and subsequent sub processes, associated with the different watch stations will be presented for evaluation. The methodology of decomposing the track management process based upon each watch station provides a more comprehensive look at the value associated with each watch station for each platform (AEGIS, SSDS).

Each of the following analyses presents aggregated data as provided by SME's. The resulting ROK's were used to focus attention to discrepancies and differences between the processes. Through an analysis of the "As Is" data, a better understanding was gained as to use of knowledge assets within in each process.

a. AEGIS Tactical Action Officer Analysis

Table 6 depicts the track management core processes involved in the KVA analysis for a TAO aboard an AEGIS platform.

Billet	Contact ID Subprocess	Number of Personnel	Actions per Hour	AWT (Hours)	Total Work Time per Hr	ALT (Hours)	NLT	IT %	TLT (Hours)	NUM	DEN	ROK
Tactical Action Officer (TAO)	**CORRELATE**											
	Obtain Link Information	1	128	0.00028	0.03556	24.0	2.0	95%	480.0	61440.0	0.0	1728.0
	Identify "Same Contact, Multiple Track"	1	40	0.00194	0.07778	24.0	1.0	20%	30.0	1200.0	0.1	15.4
	Verify Other Track Sources	1	20	0.00194	0.03889	30.0	3.0	20%	37.5	750.0	0.0	19.3
						Correl =	**0.87**			**63390.0**	**0.2**	**416.4**
	TRACK											
	Monitor Suspect Tracks	1	25	0.00194	0.04861	12.0	3.0	20%	15.0	375.0	0.0	7.7
	Update Tracks	1	10	0.00194	0.01944	6.0	2.0	30%	8.6	85.7	0.0	4.4
	Update GCCS-M	1	2	0.00139	0.00278	6.0	1.0	60%	15.0	30.0	0.0	10.8
						Correl =	**0.87**			490.7	0.1	**6.9**
	IDENTIFY											
	Verify IFF signal	1	128	0.00028	0.03556	24.0	8.0	95%	480.0	61440.0	0.0	1728.0
	Verify EW emissions	1	25	0.00139	0.03472	18.0	5.0	50%	36.0	900.0	0.0	25.9
	Verify Point of Origin	1	12	0.00278	0.03333	6.0	3.0	0%	6.0	72.0	0.0	2.2
	Match Against ATO	1	20	0.00278	0.05556	6.0	6.0	0%	6.0	120.0	0.1	2.2
	Match Against CommAir Profile	1	25	0.00028	0.00694	6.0	4.0	95%	120.0	3000.0	0.0	432.0
	Match Against Intel Information	1	25	0.00278	0.06944	30.0	9.0	0%	30.0	750.0	0.1	10.8
	Examine Kinematic Data	1	25	0.00139	0.03472	12.0	7.0	50%	24.0	600.0	0.0	17.3
	Obtain Visual ID	1	5	0.00278	0.01389	6.0	1.0	0%	6.0	30.0	0.0	2.2
	Conduct Verbal Query	1	9	0.00278	0.02500	6.0	2.0	0%	6.0	54.0	0.0	2.2
						Correl =	**0.80**			**66966.0**	**0.3**	**216.6**
	RELAY											
	Send Over Links	1	5	0.00083	0.00417	6.0	1.0	80%	30.0	150.0	0.0	36.0
	Discuss Picture with Battle Force Units	1	15	0.00278	0.04167	12.0	2.0	0%	12.0	180.0	0.0	4.3
					0.57806	**Correl =**	**1.00**			330.0	0.0	**7.2**

Table 6. "As Is" AEGIS TAO KVA Analysis

b. SSDS Tactical Action Officer Analysis

Table 7 depicts the track management core processes involved in the KVA analysis for a TAO aboard an SSDS platform.

Billet	Contact ID Subprocess	Number of Personnel	Actions per Hour	AWT (Hours)	Total Work Time per Hr	ALT (Hours)	NLT	IT %	TLT (Hours)	NUM	DEN	ROK
Tactical Action Officer (TAO)	**CORRELATE**											
	Obtain Link Information	1	128	0.00028	0.03556	8.0	2.0	95%	160.0	20480.0	0.03556	576.0
	Identify "Same Contact, Multiple Track"	1	40	0.00194	0.07778	8.0	1.0	20%	10.0	400.0	0.07778	5.1
	Verify Other Track Sources	1	20	0.00194	0.03889	10.0	3.0	20%	12.5	250.0	0.03889	6.4
						Correl =	**0.87**			**21130.0**	**0.15222**	**138.8**
	TRACK											
	Monitor Suspect Tracks	1	25	0.00194	0.04861	4.0	3.0	20%	5.0	125.0	0.04861	2.6
	Update Tracks	1	10	0.00194	0.01944	2.0	2.0	30%	2.9	28.6	0.01944	1.5
	Update GCCS-M	1	2	0.00139	0.00278	2.0	1.0	60%	5.0	10.0	0.00278	3.6
						Correl =	**0.87**			163.6	0.07083	**2.3**
	IDENTIFY											
	Verify IFF signal	1	128	0.00028	0.03556	8.0	8.0	95%	160.0	20480.0	0.03556	576.0
	Verify EW emissions	1	25	0.00139	0.03472	6.0	5.0	50%	12.0	300.0	0.03472	8.6
	Verify Point of Origin	1	12	0.00278	0.03333	2.0	3.0	0%	2.0	24.0	0.03333	0.7
	Match Against ATO	1	20	0.00278	0.05556	2.0	6.0	0%	2.0	40.0	0.05556	0.7
	Match Against CommAir Profile	1	25	0.00028	0.00694	2.0	4.0	95%	40.0	1000.0	0.00694	144.0
	Match Against Intel Information	1	25	0.00278	0.06944	10.0	9.0	0%	10.0	250.0	0.06944	3.6
	Examine Kinematic Data	1	25	0.00139	0.03472	4.0	7.0	50%	8.0	200.0	0.03472	5.8
	Obtain Visual ID	1	5	0.00278	0.01389	2.0	1.0	0%	2.0	10.0	0.01389	0.7
	Conduct Verbal Query	1	9	0.00278	0.02500	2.0	2.0	0%	2.0	18.0	0.02500	0.7
						Correl =	**0.80**			**22322.0**	**0.30917**	**72.2**
	RELAY											
	Send Over Links	1	5	0.00083	0.00417	2.0	1.0	80%	10.0	50.0	0.00417	12.0
	Discuss Picture with Battle Force Units	1	15	0.00278	0.04167	4.0	2.0	0%	4.0	60.0	0.04167	1.4
			519	**0.03028**	**0.57806**	**Correl =**	**1.00**		**447.4**	**110.0**	**0.04583**	**2.4**

Table 7. “As Is” SSDS TAO KVA Analysis

c. AEGIS Anti-Air Warfare Coordinator Analysis

Table 8 depicts the track management core processes involved in the KVA analysis for an AAWC aboard an AEGIS platform.

Billet	Contact ID Subprocess	Number of Personnel	Actions per Hour	AWT (Hours)	Total Work Time per Hr	ALT (Hours)	NLT	IT %	TLT (Hours)	NUM	DEN	ROK
Anti Air Warfare Coordinator (AAWC)	**CORRELATE**											
	Obtain Link Information	1	128	0.00028	0.03556	24.0	2.0	95%	480.0	61440.0	0.0	1728.0
	Identify "Same Contact, Multiple Track"	1	40	0.00194	0.07778	24.0	1.0	20%	30.0	1200.0	0.1	15.4
	Verify Other Track Sources	1	20	0.00194	0.03889	30.0	3.0	20%	37.5	750.0	0.0	19.3
						Correl =	**0.87**			**63390.0**	**0.2**	**416.4**
	TRACK											
	Monitor Suspect Tracks	1	25	0.00194	0.04861	12.0	2.0	20%	15.0	375.0	0.0	7.7
	Update Tracks	1	30	0.00194	0.05833	6.0	1.0	30%	8.6	257.1	0.1	4.4
						Correl =	**1.00**			632.1	0.1	**5.9**
	IDENTIFY											
	Verify IFF signal	1	128	0.00028	0.03556	24.0	8.0	95%	480.0	61440.0	0.0	1728.0
	Verify EW emissions	1	25	0.00139	0.03472	18.0	5.0	50%	36.0	900.0	0.0	25.9
	Verify Point of Origin	1	12	0.00278	0.03333	6.0	3.0	0%	6.0	72.0	0.0	2.2
	Match Against ATO	1	20	0.00278	0.05556	6.0	6.0	0%	6.0	120.0	0.1	2.2
	Match Against CommAir Profile	1	128	0.00028	0.03556	6.0	4.0	95%	120.0	15360.0	0.0	432.0
	Match Against Intel Information	1	25	0.00278	0.06944	30.0	9.0	0%	30.0	750.0	0.1	10.8
	Examine Kinematic Data	1	50	0.00139	0.06944	12.0	7.0	50%	24.0	1200.0	0.1	17.3
	Obtain Visual ID	1	5	0.00278	0.01389	6.0	1.0	0%	6.0	30.0	0.0	2.2
	Conduct Verbal Query	1	9	0.00278	0.02500	6.0	2.0	0%	6.0	54.0	0.0	2.2
						Correl =	**0.80**			**79926.0**	**0.4**	**214.6**
	RELAY											
	Send Over Links	1	5	0.00083	0.00417	6.0	1.0	80%	30.0	150.0	0.0	36.0
	Discuss Picture with Battle Force Units	1	50	0.00278	0.13889	12.0	2.0	0%	12.0	600.0	0.1	4.3
					0.77472	**Correl =**	**1.00**			750.0	0.1	**5.2**

Table 8. “As Is” AEGIS AAWC KVA Analysis

d. SSDS Anti-Air Warfare Coordinator Analysis

Table 9 depicts the track management core processes involved in the KVA analysis for an AAWC aboard an SSDS platform.

Billet	Contact ID Subprocess	Number of Personnel	Actions per Hour	AWT (Hours)	Total Work Time per Hr	ALT (Hours)	NLT	IT %	TLT (Hours)	NUM	DEN	ROK
Anti Air Warfare Coordinator (AAWC)	**CORRELATE**											
	Obtain Link Information	1	128	0.00028	0.03556	8.0	2.0	95%	160.0	20480.0	0.03556	576.0
	Identify "Same Contact, Multiple Track"	1	40	0.00194	0.07778	8.0	1.0	20%	10.0	400.0	0.07778	5.1
	Verify Other Track Sources	1	20	0.00194	0.03889	10.0	3.0	20%	12.5	250.0	0.03889	6.4
						Correl =	**0.87**			**21130.0**	**0.15222**	**138.8**
	TRACK											
	Monitor Suspect Tracks	1	25	0.00194	0.04861	4.0	2.0	20%	5.0	125.0	0.04861	2.6
	Update Tracks	1	30	0.00194	0.05833	2.0	1.0	30%	2.9	85.7	0.05833	1.5
						Correl =	**1.00**			210.7	0.10694	**2.0**
	IDENTIFY											
	Verify IFF signal	1	128	0.00028	0.03556	8.0	8.0	95%	160.0	20480.0	0.03556	576.0
	Verify EW emissions	1	25	0.00139	0.03472	6.0	5.0	50%	12.0	300.0	0.03472	8.6
	Verify Point of Origin	1	12	0.00278	0.03333	2.0	3.0	0%	2.0	24.0	0.03333	0.7
	Match Against ATO	1	20	0.00278	0.05556	2.0	6.0	0%	2.0	40.0	0.05556	0.7
	Match Against CommAir Profile	1	128	0.00028	0.03556	2.0	4.0	95%	40.0	5120.0	0.03556	144.0
	Match Against Intel Information	1	25	0.00278	0.06944	10.0	9.0	0%	10.0	250.0	0.06944	3.6
	Examine Kinematic Data	1	50	0.00139	0.06944	4.0	7.0	50%	8.0	400.0	0.06944	5.8
	Obtain Visual ID	1	5	0.00278	0.01389	2.0	1.0	0%	2.0	10.0	0.01389	0.7
	Conduct Verbal Query	1	9	0.00278	0.02500	2.0	2.0	0%	2.0	18.0	0.02500	0.7
						Correl =	**0.80**			**26642.0**	**0.37250**	**71.5**
	RELAY											
	Send Over Links	1	5	0.00083	0.00417	2.0	1.0	80%	10.0	50.0	0.00417	12.0
	Discuss Picture with Battle Force Units	1	50	0.00278	0.13889	4.0	2.0	0%	4.0	200.0	0.13889	1.4
					0.77472	**Correl =**	**1.00**			250.0	0.14306	**1.7**

Table 9. “As Is” SSDS AAWC KVA Analysis

e. AEGIS Surface Warfare Coordinator

Table 10 depicts the track management core processes involved in the KVA analysis for an SUWC aboard an AEGIS platform.

Billet	Contact ID Subprocess	Number of Personnel	Actions per Hour	AWT (Hours)	Total Work Time per Hr	ALT (Hours)	NLT	IT %	TLT (Hours)	NUM	DEN	ROK
Surface Warfare Coordinator (SUWC)	**CORRELATE**											
	Obtain Link Information	1	64	0.00028	0.01778	24.0	2.0	95%	480.0	30720.0	0.0	1728.0
	Identify "Same Contact, Multiple Track"	1	2	0.00194	0.00389	24.0	1.0	20%	30.0	60.0	0.0	15.4
	Verify Other Track Sources	1	20	0.00194	0.03889	30.0	3.0	20%	37.5	750.0	0.0	19.3
						Correl =	**0.87**			**31530.0**	**0.1**	**520.7**
	TRACK											
	Monitor Suspect Tracks	1	1	0.00194	0.00194	12.0	3.0	20%	15.0	15.0	0.0	7.7
	Update Tracks	1	10	0.00194	0.01944	6.0	2.0	30%	8.6	85.7	0.0	4.4
	Update GCCS-M	1	20	0.00139	0.02778	6.0	1.0	60%	15.0	300.0	0.0	10.8
						Correl =	**0.87**			400.7	0.0	**8.2**
	IDENTIFY											
	Verify IFF signal	1	6	0.00028	0.00167	24.0	6.0	95%	480.0	2880.0	0.0	1728.0
	Verify EW emissions	1	15	0.00139	0.02083	18.0	4.0	50%	36.0	540.0	0.0	25.9
	Verify Point of Origin	1	1	0.00278	0.00278	6.0	3.0	0%	6.0	6.0	0.0	2.2
	Match Against Intel Information	1	5	0.00278	0.01389	30.0	7.0	0%	30.0	150.0	0.0	10.8
	Examine Kinematic Data	1	64	0.00139	0.08889	12.0	5.0	50%	24.0	1536.0	0.1	17.3
	Obtain Visual ID	1	5	0.00278	0.01389	6.0	1.0	0%	6.0	30.0	0.0	2.2
	Conduct Verbal Query	1	9	0.00278	0.02500	6.0	2.0	0%	6.0	54.0	0.0	2.2
						Correl =	**0.91**			**5196.0**	**0.2**	**31.1**
	RELAY											
	Send Over Links	1	1	0.00083	0.00083	6.0	1.0	80%	30.0	30.0	0.0	36.0
	Discuss Picture with Battle Force Units	1	5	0.00278	0.01389	12.0	2.0	0%	12.0	60.0	0.0	4.3
					0.29139	**Correl =**	**1.00**			90.0	0.0	**6.1**

Table 10. “As Is” AEGIS SUWC KVA Analysis

f. SSDS Surface Warfare Coordinator

Table 11 depicts the track management core processes involved in the KVA analysis for an SUWC aboard an SSDS platform.

Billet	Contact ID Subprocess	Number of Personnel	Actions per Hour	AWT (Hours)	Total Work Time per Hr	ALT (Hours)	NLT	IT %	TLT (Hours)	NUM	DEN	ROK
Surface Warfare Coordinator (SUWC)	**CORRELATE**											
	Obtain Link Information	1	64	0.00028	0.01778	8.0	2.0	95%	160.0	10240.0	0.01778	576.0
	Identify "Same Contact, Multiple Track"	1	2	0.00194	0.00389	8.0	1.0	20%	10.0	20.0	0.00389	5.1
	Verify Other Track Sources	1	20	0.00194	0.03889	10.0	3.0	20%	12.5	250.0	0.03889	6.4
						Correl =	**0.87**			**10510.0**	**0.06056**	**173.6**
	TRACK											
	Monitor Suspect Tracks	1	1	0.00194	0.00194	4.0	3.0	20%	5.0	5.0	0.00194	2.6
	Update Tracks	1	10	0.00194	0.01944	2.0	2.0	30%	2.9	28.6	0.01944	1.5
	Update GCCS-M	1	20	0.00139	0.02778	2.0	1.0	60%	5.0	100.0	0.02778	3.6
						Correl =	**0.87**			133.6	0.04917	**2.7**
	IDENTIFY											
	Verify IFF signal	1	6	0.00028	0.00167	8.0	6.0	95%	160.0	960.0	0.00167	576.0
	Verify EW emissions	1	15	0.00139	0.02083	6.0	4.0	50%	12.0	180.0	0.02083	8.6
	Verify Point of Origin	1	1	0.00278	0.00278	2.0	3.0	0%	2.0	2.0	0.00278	0.7
	Match Against Intel Information	1	5	0.00278	0.01389	10.0	7.0	0%	10.0	50.0	0.01389	3.6
	Examine Kinematic Data	1	64	0.00139	0.08889	4.0	5.0	50%	8.0	512.0	0.08889	5.8
	Obtain Visual ID	1	5	0.00278	0.01389	2.0	1.0	0%	2.0	10.0	0.01389	0.7
	Conduct Verbal Query	1	9	0.00278	0.02500	2.0	2.0	0%	2.0	18.0	0.02500	0.7
						Correl =	**0.91**			**1732.0**	**0.16694**	**10.4**
	RELAY											
	Send Over Links	1	1	0.00083	0.00083	2.0	1.0	80%	10.0	10.0	0.00083	12.0
	Discuss Picture with Battle Force Units	1	5	0.00278	0.01389	4.0	2.0	0%	4.0	20.0	0.01389	1.4
					0.29139	**Correl =**	**1.00**			30.0	0.01472	**2.0**

Table 11. “As Is” SSDS SUWC KVA Analysis

g. AEGIS Combat Systems Coordinator

Table 12 depicts the track management core processes involved in the KVA analysis for a CSC aboard an AEGIS platform.

Billet	Contact ID Subprocess	Number of Personnel	Actions per Hour	AWT (Hours)	Total Work Time per Hr	ALT (Hours)	NLT	IT %	TLT (Hours)	NUM	DEN	ROK
Combat Systems Coordinator (CSC)	**CORRELATE**											
	Obtain Link Information	1	128	0.00028	0.03556	6.0	2.0	95%	120.0	15360.0	0.0	432.0
	Identify "Same Contact, Multiple Track"	1	40	0.00194	0.07778	6.0	1.0	20%	7.5	300.0	0.1	3.9
	Verify Other Track Sources	1	20	0.00194	0.03889	8.0	3.0	20%	10.0	200.0	0.0	5.1
						Correl =	**0.87**			**15860.0**	**0.2**	**104.2**
	TRACK											
	Monitor Suspect Tracks	1	25	0.00194	0.04861	3.0	2.0	20%	3.8	93.8	0.0	1.9
	Update Tracks	1	10	0.00194	0.01944	2.0	1.0	30%	2.9	28.6	0.0	1.5
						Correl =	**1.00**			122.3	0.1	**1.8**
	IDENTIFY											
	Verify IFF signal	1	10	0.00028	0.00278	6.0	6.0	95%	120.0	1200.0	0.0	432.0
	Verify EW emissions	1	25	0.00139	0.03472	5.0	3.0	50%	10.0	250.0	0.0	7.2
	Verify Point of Origin	1	1	0.00278	0.00278	2.0	1.0	0%	2.0	2.0	0.0	0.7
	Match Against ATO	1	2	0.00278	0.00556	2.0	4.0	0%	2.0	4.0	0.0	0.7
	Match Against CommAir Profile	1	128	0.00028	0.03556	2.0	2.0	95%	40.0	5120.0	0.0	144.0
	Match Against Intel Information	1	25	0.00278	0.06944	10.0	7.0	0%	10.0	250.0	0.1	3.6
	Examine Kinematic Data	1	50	0.00139	0.06944	4.0	5.0	50%	8.0	400.0	0.1	5.8
						Correl =	**0.81**			**7226.0**	**0.2**	**32.8**
	RELAY											
	Send Over Links	1	1	0.00083	0.00083	2.0	1.0	80%	10.0	10.0	0.0	12.0
					0.44139	**Correl =**	**1.00**			10.0	0.0	**12.0**

Table 12. “As Is” AEGIS CSC KVA Analysis

h. SSDS Combat Systems Coordinator

Table 13 depicts the track management core processes involved in the KVA analysis for a CSC aboard an SSDS platform.

Billet	Contact ID Subprocess	Number of Personnel	Actions per Hour	AWT (Hours)	Total Work Time per Hr	ALT (Hours)	NLT	IT %	TLT (Hours)	NUM	DEN	ROK
Combat Systems Coordinator (CSC)	**CORRELATE**											
	Obtain Link Information	1	128	0.00028	0.03556	8.0	2.0	95%	160.0	20480.0	0.03556	576.0
	Identify "Same Contact, Multiple Track"	1	40	0.00194	0.07778	8.0	1.0	20%	10.0	400.0	0.07778	5.1
	Verify Other Track Sources	1	20	0.00194	0.03889	10.0	3.0	20%	12.5	250.0	0.03889	6.4
						Correl =	**0.87**			**21130.0**	**0.15222**	**138.8**
	TRACK											
	Monitor Suspect Tracks	1	25	0.00194	0.04861	4.0	2.0	20%	5.0	125.0	0.04861	2.6
	Update Tracks	1	10	0.00194	0.01944	2.0	1.0	30%	2.9	28.6	0.01944	1.5
						Correl =	**1.00**			153.6	0.06806	**2.3**
	IDENTIFY											
	Verify IFF signal	1	10	0.00028	0.00278	8.0	6.0	95%	160.0	1600.0	0.00278	576.0
	Verify EW emissions	1	25	0.00139	0.03472	6.0	3.0	50%	12.0	300.0	0.03472	8.6
	Verify Point of Origin	1	1	0.00278	0.00278	2.0	1.0	0%	2.0	2.0	0.00278	0.7
	Match Against ATO	1	2	0.00278	0.00556	2.0	4.0	0%	2.0	4.0	0.00556	0.7
	Match Against CommAir Profile	1	128	0.00028	0.03556	2.0	2.0	95%	40.0	5120.0	0.03556	144.0
	Match Against Intel Information	1	25	0.00278	0.06944	10.0	7.0	0%	10.0	250.0	0.06944	3.6
	Examine Kinematic Data	1	50	0.00139	0.06944	4.0	5.0	50%	8.0	400.0	0.06944	5.8
						Correl =	**0.81**			**7676.0**	**0.22028**	**34.8**
	RELAY											
	Send Over Links	1	1	0.00083	0.00083	2.0	1.0	80%	10.0	10.0	0.00083	12.0
					0.44139	**Correl =**	**1.00**			10.0	0.00083	**12.0**

Table 13. “As Is” SSDS CSC KVA Analysis

i. AEGIS Tactical Information Coordinator

Table 14 depicts the track management core processes involved in the KVA analysis for a TIC aboard an AEGIS platform.

Billet	Contact ID Subprocess	Number of Personnel	Actions per Hour	AWT (Hours)	Total Work Time per Hr	ALT (Hours)	NLT	IT %	TLT (Hours)	NUM	DEN	ROK
Tactical Information Coordinator (TIC)	**CORRELATE**											
	Obtain Link Information	1	128	0.00028	0.03556	8.0	2.0	95%	160.0	20480.0	0.0	576.0
	Identify "Same Contact, Multiple Track"	1	40	0.00194	0.07778	8.0	1.0	20%	10.0	400.0	0.1	5.1
	Verify Other Track Sources	1	20	0.00194	0.03889	10.0	3.0	20%	12.5	250.0	0.0	6.4
						Correl =	**0.87**			**21130.0**	**0.2**	**138.8**
	TRACK											
	Monitor Suspect Tracks	1	25	0.00194	0.04861	4.0	2.0	20%	5.0	125.0	0.0	2.6
	Update Tracks	1	64	0.00194	0.12444	2.0	1.0	30%	2.9	182.9	0.1	1.5
						Correl =	**1.00**			307.9	0.2	**1.8**
	IDENTIFY											
	Verify IFF signal	1	182	0.00028	0.05056	8.0	8.0	95%	160.0	29120.0	0.1	576.0
	Verify EW emissions	1	25	0.00139	0.03472	6.0	5.0	50%	12.0	300.0	0.0	8.6
	Verify Point of Origin	1	12	0.00278	0.03333	2.0	3.0	0%	2.0	24.0	0.0	0.7
	Match Against ATO	1	20	0.00278	0.05556	2.0	6.0	0%	2.0	40.0	0.1	0.7
	Match Against CommAir Profile	1	182	0.00028	0.05056	2.0	4.0	95%	40.0	7280.0	0.1	144.0
	Match Against Intel Information	1	25	0.00278	0.06944	10.0	9.0	0%	10.0	250.0	0.1	3.6
	Examine Kinematic Data	1	100	0.00139	0.13889	4.0	7.0	50%	8.0	800.0	0.1	5.8
	Obtain Visual ID	1	5	0.00278	0.01389	2.0	1.0	0%	2.0	10.0	0.0	0.7
	Conduct Verbal Query	1	9	0.00278	0.02500	2.0	2.0	0%	2.0	18.0	0.0	0.7
						Correl =	**0.80**			**37842.0**	**0.5**	**80.2**
	RELAY											
	Send Over Links	1	5	0.00083	0.00417	2.0	1.0	80%	10.0	50.0	0.0	12.0
	Discuss Picture with Battle Force Units	1	25	0.00278	0.06944	4.0	2.0	0%	4.0	100.0	0.1	1.4
					0.87083	**Correl =**	**1.00**			150.0	0.1	**2.0**

Table 14. “As Is” AEGIS TIC KVA Analysis

j. SSDS Tactical Information Coordinator

Table 15 depicts the track management core processes involved in the KVA analysis for a TIC aboard an SSDS platform.

Billet	Contact ID Subprocess	Number of Personnel	Actions per Hour	AWT (Hours)	Total Work Time per Hr	ALT (Hours)	NLT	IT %	TLT (Hours)	NUM	DEN	ROK
Tactical Information Coordinator (TIC)	**CORRELATE**											
	Obtain Link Information	1	128	0.00028	0.03556	8.0	2.0	95%	160.0	20480.0	0.03556	576.0
	Identify "Same Contact, Multiple Track"	1	40	0.00194	0.07778	8.0	1.0	20%	10.0	400.0	0.07778	5.1
	Verify Other Track Sources	1	20	0.00194	0.03889	10.0	3.0	20%	12.5	250.0	0.03889	6.4
						Correl =	**0.87**			**21130.0**	**0.15222**	**138.8**
	TRACK											
	Monitor Suspect Tracks	1	25	0.00194	0.04861	4.0	2.0	20%	5.0	125.0	0.04861	2.6
	Update Tracks	1	64	0.00194	0.12444	2.0	1.0	30%	2.9	182.9	0.12444	1.5
						Correl =	**1.00**			307.9	0.17306	**1.8**
	IDENTIFY											
	Verify IFF signal	1	182	0.00028	0.05056	8.0	8.0	95%	160.0	29120.0	0.05056	576.0
	Verify EW emissions	1	25	0.00139	0.03472	6.0	5.0	50%	12.0	300.0	0.03472	8.6
	Verify Point of Origin	1	12	0.00278	0.03333	2.0	3.0	0%	2.0	24.0	0.03333	0.7
	Match Against ATO	1	20	0.00278	0.05556	2.0	6.0	0%	2.0	40.0	0.05556	0.7
	Match Against CommAir Profile	1	182	0.00028	0.05056	2.0	4.0	95%	40.0	7280.0	0.05056	144.0
	Match Against Intel Information	1	25	0.00278	0.06944	10.0	9.0	0%	10.0	250.0	0.06944	3.6
	Examine Kinematic Data	1	100	0.00139	0.13889	4.0	7.0	50%	8.0	800.0	0.13889	5.8
	Obtain Visual ID	1	5	0.00278	0.01389	2.0	1.0	0%	2.0	10.0	0.01389	0.7
	Conduct Verbal Query	1	9	0.00278	0.02500	2.0	2.0	0%	2.0	18.0	0.02500	0.7
						Correl =	**0.80**			**37842.0**	**0.47194**	**80.2**
	RELAY											
	Send Over Links	1	5	0.00083	0.00417	2.0	1.0	80%	10.0	50.0	0.00417	12.0
	Discuss Picture with Battle Force Units	1	25	0.00278	0.06944	4.0	2.0	0%	4.0	100.0	0.06944	1.4
					0.87083	**Correl =**	**1.00**			150.0	0.07361	**2.0**

Table 15. “As Is” SSDS TIC KVA Analysis

k. AEGIS Identification Supervisor

Table 16 depicts the track management core processes involved in the KVA analysis for an IDS aboard an AEGIS platform.

Billet	Contact ID Subprocess	Number of Personnel	Actions per Hour	AWT (Hours)	Total Work Time per Hr	ALT (Hours)	NLT	IT %	TLT (Hours)	NUM	DEN	ROK
Identification Supervisor (IDS)	**CORRELATE**											
	Obtain Link Information	1	128	0.00028	0.03556	8.0	2.0	95%	160.0	20480.0	0.0	576.0
	Identify "Same Contact, Multiple Track"	1	40	0.00194	0.07778	8.0	1.0	20%	10.0	400.0	0.1	5.1
	Verify Other Track Sources	1	20	0.00194	0.03889	10.0	3.0	20%	12.5	250.0	0.0	6.4
						Correl =	**0.87**			**21130.0**	**0.2**	**138.8**
	TRACK											
	Monitor Suspect Tracks	1	25	0.00194	0.04861	4.0	2.0	20%	5.0	125.0	0.0	2.6
	Update Tracks	1	64	0.00194	0.12444	2.0	1.0	30%	2.9	182.9	0.1	1.5
						Correl =	**1.00**			307.9	0.2	**1.8**
	IDENTIFY											
	Verify IFF signal	1	182	0.00028	0.05056	8.0	8.0	95%	160.0	29120.0	0.1	576.0
	Verify EW emissions	1	25	0.00139	0.03472	6.0	5.0	50%	12.0	300.0	0.0	8.6
	Verify Point of Origin	1	12	0.00278	0.03333	2.0	3.0	0%	2.0	24.0	0.0	0.7
	Match Against ATO	1	20	0.00278	0.05556	2.0	6.0	0%	2.0	40.0	0.1	0.7
	Match Against CommAir Profile	1	182	0.00028	0.05056	2.0	4.0	95%	40.0	7280.0	0.1	144.0
	Match Against Intel Information	1	10	0.00278	0.02778	10.0	9.0	0%	10.0	100.0	0.0	3.6
	Examine Kinematic Data	1	105	0.00139	0.14583	4.0	7.0	50%	8.0	840.0	0.1	5.8
	Obtain Visual ID	1	5	0.00278	0.01389	2.0	1.0	0%	2.0	10.0	0.0	0.7
	Conduct Verbal Query	1	9	0.00278	0.02500	2.0	2.0	0%	2.0	18.0	0.0	0.7
						Correl =	**0.80**			**37732.0**	**0.4**	**86.3**
	RELAY											
	Send Over Links	1	64	0.00083	0.05333	2.0	1.0	80%	10.0	640.0	0.1	12.0
	Discuss Picture with Battle Force Units	1	64	0.00278	0.17778	4.0	2.0	0%	4.0	256.0	0.2	1.4
					0.99361	**Correl =**	**1.00**			896.0	0.2	**3.9**

Table 16. “As Is” AEGIS IDS KVA Analysis

l. SSDS Identification Supervisor

Table 17 depicts the track management core processes involved in the KVA analysis for an IDS aboard an SSDS platform.

Billet	Contact ID Subprocess	Number of Personnel	Actions per Hour	AWT (Hours)	Total Work Time per Hr	ALT (Hours)	NLT	IT %	TLT (Hours)	NUM	DEN	ROK
Identification Supervisor (IDS)	**CORRELATE**											
	Obtain Link Information	1	128	0.00028	0.03556	8.0	2.0	95%	160.0	20480.0	0.03556	576.0
	Identify "Same Contact, Multiple Track"	1	40	0.00194	0.07778	8.0	1.0	20%	10.0	400.0	0.07778	5.1
	Verify Other Track Sources	1	20	0.00194	0.03889	10.0	3.0	20%	12.5	250.0	0.03889	6.4
						Correl =	**0.87**			**21130.0**	**0.15222**	**138.8**
	TRACK											
	Monitor Suspect Tracks	1	25	0.00194	0.04861	4.0	2.0	20%	5.0	125.0	0.04861	2.6
	Update Tracks	1	64	0.00194	0.12444	2.0	1.0	30%	2.9	182.9	0.12444	1.5
						Correl =	**1.00**			307.9	0.17306	**1.8**
	IDENTIFY											
	Verify IFF signal	1	182	0.00028	0.05056	8.0	8.0	95%	160.0	29120.0	0.05056	576.0
	Verify EW emissions	1	25	0.00139	0.03472	6.0	5.0	50%	12.0	300.0	0.03472	8.6
	Verify Point of Origin	1	12	0.00278	0.03333	2.0	3.0	0%	2.0	24.0	0.03333	0.7
	Match Against ATO	1	20	0.00278	0.05556	2.0	6.0	0%	2.0	40.0	0.05556	0.7
	Match Against CommAir Profile	1	182	0.00028	0.05056	2.0	4.0	95%	40.0	7280.0	0.05056	144.0
	Match Against Intel Information	1	10	0.00278	0.02778	10.0	9.0	0%	10.0	100.0	0.02778	3.6
	Examine Kinematic Data	1	105	0.00139	0.14583	4.0	7.0	50%	8.0	840.0	0.14583	5.8
	Obtain Visual ID	1	5	0.00278	0.01389	2.0	1.0	0%	2.0	10.0	0.01389	0.7
	Conduct Verbal Query	1	9	0.00278	0.02500	2.0	2.0	0%	2.0	18.0	0.02500	0.7
						Correl =	**0.80**			**37732.0**	**0.43722**	**86.3**
	RELAY											
	Send Over Links	1	64	0.00083	0.05333	2.0	1.0	80%	10.0	640.0	0.05333	12.0
	Discuss Picture with Battle Force Units	1	64	0.00278	0.17778	4.0	2.0	0%	4.0	256.0	0.17778	1.4
					0.99361	**Correl =**	**1.00**			896.0	0.23111	**3.9**

Table 17. “As Is” SSDS IDS KVA Analysis

F. “TO BE” KVA ANALYSIS

The “To Be” analysis is a notional representation of the possible effects given a futuristic scenario that incorporates changes to the sub processes. For the purposes of this analysis, sub processes that could possibly be affected through the use of an open architectural framework have been adjusted to reflect the changes. Only those processes that could be affected will be provided in this section. Sub processes that would not be affected through the application of an open architecture are not presented in this section, and should be considered to remain unchanged.

1. Open Architecture Reengineering

Through an analysis of the “As Is” processes, it was determined that the optimal enhancements to an operational environment could be achieved in the areas of systems integration and hardware scalability through the application of open architecture. The analysis was focused through the ROK results, but was not limited to only using ROK as a determining factor. The ROK results led to more pointed questions:

- Why were the “Obtain Link Information” and “Verify IFF Signal” ROK’s orders of magnitude greater than the other processes?
- Why was there a difference in some process ROK’s between watch stations across the platforms?
- Should all watch stations be trained for each of the sub processes?

Taking this idea and reengineering the processes involving these areas provided increases in the ROK for each sub process. For the purposes of this research, the effect of training time through open architecture could not be determined, so the category was left unchanged. Assumptions for the reengineering methodology were: 1) integration through the use of middleware was necessary until Category 3 OACE level could be reached for systems being evaluated and 2) hardware would be Commercial-Off-The-Shelf (COTS) equipment.

2. "To Be" Process Data

In presenting the following scenarios it was necessary to estimate the changes in "AWT" and "%IT" categories due to the fact that the "To Be" analysis is an estimation. For all scenarios it was assumed that a transformation to open architecture would automate a sub process to the extent that the "%IT" category would be 95%. Automation in these sub processes would result in a decrease in "AWT" as it would no longer be necessary for a watch stander to be involved in the conduct of the sub process, so the time needed to complete the action would be reduced.

The sub processes affected were "Update GCCS-M", "Verify EW Emissions", "Verify Point of Origin" and "Match against ATO". Each of the watch stations was affected, though some more than others as not all sub processes were applicable to all watch stations. Tables 19 through 30 represent the analysis of each watch station after a notional reengineering of the sub processes occurs.

The "Update GCCS-M" sub process could be affected through an application of a middle ware product until the AEGIS and SSDS platforms could reach a Category 3 OACE level. The current version of GCCS-M provides an "open-system commercial and government standards-based architecture that maximizes use of non-developmental items and is in compliance with the Global Information Grid-Enterprise Services to ensure interoperability with U.S. Joint and other naval C4I systems" (Globalsecurity.org). Due to its use of OA it was determined to be a candidate for incorporation into an AEGIS or SSDS platform that conformed to open architecture standards. While some critical interfaces have yet to be tested, it would be a means to enhance the operational value of the systems through a reduction in time, manpower and possible training required to conduct the process.

“Verify EW Emissions” is hindered through hardware limitations due to the proprietary nature of the equipment. Applying an open architecture framework to the EW systems would facilitate a COTS based environment that could easily be upgraded to accommodate greater processor speeds. The ability to communicate the data from the EW systems electronically to the CIC personnel that require it would greatly enhance the efficiency of the CIC through more timely situational awareness. Operators would be freed up to conduct other tasks that they would otherwise not have time to accomplish.

“Verify Point of Origin” sub process could be enhanced through better integration of sensors within the AEGIS and SSDS platforms. An open architecture framework could enable greater sensor and data integration which would provide more enhanced correlation to pinpoint the point of origin of an aircraft or ship. Point of origin for friendly force contacts could be queried from an open GCCS-M system and ATO, while neutral force contacts could be interrogated from host nation airports, assuming data formats were standardized and provided by host nations. Presenting an open architecture framework to the AEGIS and SSDS platforms could facilitate interfaces to these other systems in order to provide an automated query for point of origin. The automation of this sub process would free up watch standers to accomplish other tasks, while at the same time providing quicker data flow.

Lastly, the sub process “Match Against ATO” could be greatly enhanced through an open architecture framework. Current initiatives are being looked into for feasibility of integrating the ATO into surface combat ships though an automatic parsing and feeding of messages into ID engines on AEGIS and SSDS platforms. Using LINK 11 or LINK 16, data could be fed into the systems. Through an application of middleware and COTS hardware, the information provided in the ATO could be integrated into the AEGIS and SSDS platforms, greatly reducing the manpower required to accomplish this sub process.

a. AEGIS Tactical Action Officer Analysis

Table 18 depicts the notional track management core processes involved in the KVA analysis for a TAO aboard an AEGIS platform after reengineering with an open architecture approach.

Billet	Contact ID Subprocess	Number of Personnel	Actions per Hour	AWT (Hours)	Total Work Time per Hr	ALT (Hours)	NLT	IT %	TLT (Hours)	NUM	DEN	ROK
Tactical Action Officer (TAO)	TRACK											
	Update GCCS-M	1	2	0.00028	0.00056	6.0	1.0	95%	120.0	240.0	0.0	432.0
	IDENTIFY											
	Verify EW emissions	1	25	0.00028	0.00694	18.0	5.0	95%	360.0	9000.0	0.0	1296.0
	Verify Point of Origin	1	12	0.00028	0.00333	6.0	3.0	95%	120.0	1440.0	0.0	432.0
	Match Against ATO	1	20	0.00028	0.00556	6.0	6.0	95%	120.0	2400.0	0.0	432.0

Table 18. “To Be” AEGIS TAO KVA Analysis

b. SSDS Tactical Action Officer Analysis

Table 19 depicts the notional track management core processes involved in the KVA analysis for a TAO aboard an SSDS platform after reengineering with an open architecture approach.

Billet	Contact ID Subprocess	Number of Personnel	Actions per Hour	AWT (Hours)	Total Work Time per Hr	ALT (Hours)	NLT	IT %	TLT (Hours)	NUM	DEN	ROK
Tactical Action Officer (TAO)	TRACK											
	Update GCCS-M	1	2	0.00028	0.00056	2.0	1.0	95%	40.0	80.0	0.0	144.0
	IDENTIFY											
	Verify EW emissions	1	25	0.00028	0.00694	6.0	5.0	95%	120.0	3000.0	0.0	432.0
	Verify Point of Origin	1	12	0.00028	0.00333	2.0	3.0	95%	40.0	480.0	0.0	144.0
	Match Against ATO	1	20	0.00028	0.00556	2.0	6.0	95%	40.0	800.0	0.0	144.0

Table 19. “To Be” SSDS TAO KVA Analysis

c. AEGIS Anti-Air Warfare Coordinator

Table 20 depicts the notional track management core processes involved in the KVA analysis for an AAWC aboard an AEGIS platform after reengineering with an open architecture approach.

Billet	Contact ID Subprocess	Number of Personnel	Actions per Hour	AWT (Hours)	Total Work Time per Hr	ALT (Hours)	NLT	IT %	TLT (Hours)	NUM	DEN	ROK
Anti Air Warfare Coordinator (AAWC)	IDENTIFY											
	Verify EW emissions	1	25	0.00028	0.00694	18.0	5.0	95%	360.0	9000.0	0.0	1296.0
	Verify Point of Origin	1	12	0.00028	0.00333	6.0	3.0	95%	120.0	1440.0	0.0	432.0
	Match Against ATO	1	20	0.00028	0.00556	6.0	6.0	95%	120.0	2400.0	0.0	432.0

Table 20. “To Be” AEGIS AAWC KVA Analysis

d. SSDS Anti-Air Warfare Coordinator

Table 21 depicts the notional track management core processes involved in the KVA analysis for an AAWC aboard an SSDS platform after reengineering with an open architecture approach.

Billet	Contact ID Subprocess	Number of Personnel	Actions per Hour	AWT (Hours)	Total Work Time per Hr	ALT (Hours)	NLT	IT %	TLT (Hours)	NUM	DEN	ROK
Anti Air Warfare Coordinator (AAWC)	IDENTIFY											
	Verify EW emissions	1	25	0.00028	0.00694	6.0	5.0	95%	120.0	3000.0	0.0	432.0
	Verify Point of Origin	1	12	0.00028	0.00333	2.0	3.0	95%	40.0	480.0	0.0	144.0
	Match Against ATO	1	20	0.00028	0.00556	2.0	6.0	95%	40.0	800.0	0.0	144.0

Table 21. “To Be” SSDS AAWC KVA Analysis

e. AEGIS Surface Warfare Coordinator

Table 22 depicts the notional track management core processes involved in the KVA analysis for an SUWC aboard an AEGIS platform after reengineering with an open architecture approach.

Billet	Contact ID Subprocess	Number of Personnel	Actions per Hour	AWT (Hours)	Total Work Time per Hr	ALT (Hours)	NLT	IT %	TLT (Hours)	NUM	DEN	ROK
Surface Warfare Coordinator (SUWC)	**TRACK**											
	Update GCCS-M	1	20	0.00028	0.00556	6.0	1.0	95%	120.0	2400.0	0.0	432.0
	IDENTIFY											
	Verify EW emissions	1	15	0.00028	0.00417	18.0	4.0	95%	360.0	5400.0	0.0	1296.0
	Verify Point of Origin	1	1	0.00028	0.00028	6.0	3.0	95%	120.0	120.0	0.0	432.0

Table 22. “To Be” AEGIS SUWC KVA Analysis

f. SSDS Surface Warfare Coordinator

Table 23 depicts the notional track management core processes involved in the KVA analysis for an SUWC aboard an SSDS platform after reengineering with an open architecture approach.

Billet	Contact ID Subprocess	Number of Personnel	Actions per Hour	AWT (Hours)	Total Work Time per Hr	ALT (Hours)	NLT	IT %	TLT (Hours)	NUM	DEN	ROK
Surface Warfare Coordinator (SUWC)	**TRACK**											
	Update GCCS-M	1	20	0.00028	0.00556	2.0	1.0	95%	40.0	800.0	0.0	144.0
	IDENTIFY											
	Verify EW emissions	1	15	0.00028	0.00417	6.0	4.0	95%	120.0	1800.0	0.0	432.0
	Verify Point of Origin	1	1	0.00028	0.00028	2.0	3.0	95%	40.0	40.0	0.0	144.0

Table 23. “To Be” SSDS SUWC KVA Analysis

g. AEGIS Combat Systems Coordinator

Table 24 depicts the notional track management core processes involved in the KVA analysis for a CSC aboard an AEGIS platform after reengineering with an open architecture approach.

Billet	Contact ID Subprocess	Number of Personnel	Actions per Hour	AWT (Hours)	Total Work Time per Hr	ALT (Hours)	NLT	IT %	TLT (Hours)	NUM	DEN	ROK
Combat Systems Coordinator (CSC)	**IDENTIFY**											
	Verify EW emissions	1	25	0.00028	0.00694	5.0	3.0	95%	100.0	2500.0	0.0	360.0
	Verify Point of Origin	1	1	0.00028	0.00028	2.0	1.0	95%	40.0	40.0	0.0	144.0
	Match Against ATO	1	2	0.00028	0.00056	2.0	4.0	95%	40.0	80.0	0.0	144.0

Table 24. “To Be” AEGIS CSC KVA Analysis

h. SSDS Combat Systems Coordinator

Table 25 depicts the notional track management core processes involved in the KVA analysis for a CSC aboard an SSDS platform after reengineering with an open architecture approach.

Billet	Contact ID Subprocess	Number of Personnel	Actions per Hour	AWT (Hours)	Total Work Time per Hr	ALT (Hours)	NLT	IT %	TLT (Hours)	NUM	DEN	ROK
Combat Systems Coordinator (CSC)	IDENTIFY											
	Verify EW emissions	1	25	0.00028	0.00694	6.0	3.0	95%	120.0	3000.0	0.0	432.0
	Verify Point of Origin	1	1	0.00028	0.00028	2.0	1.0	95%	40.0	40.0	0.0	144.0
	Match Against ATO	1	2	0.00028	0.00056	2.0	4.0	95%	40.0	80.0	0.0	144.0

Table 25. “To Be” SSDS CSC KVA Analysis

i. AEGIS Tactical Information Coordinator

Table 26 depicts the notional track management core processes involved in the KVA analysis for a TIC aboard an AEGIS platform after reengineering with an open architecture approach.

Billet	Contact ID Subprocess	Number of Personnel	Actions per Hour	AWT (Hours)	Total Work Time per Hr	ALT (Hours)	NLT	IT %	TLT (Hours)	NUM	DEN	ROK
Tactical Information Coordinator (TIC)	IDENTIFY											
	Verify EW emissions	1	25	0.00028	0.00694	6.0	5.0	95%	120.0	3000.0	0.0	432.0
	Verify Point of Origin	1	12	0.00028	0.00333	2.0	3.0	95%	40.0	480.0	0.0	144.0
	Match Against ATO	1	20	0.00028	0.00556	2.0	6.0	95%	40.0	800.0	0.0	144.0

Table 26. “To Be” AEGIS TIC KVA Analysis

j. SSDS Tactical Information Coordinator

Table 27 depicts the notional track management core processes involved in the KVA analysis for a TIC aboard an SSDS platform after reengineering with an open architecture approach.

Billet	Contact ID Subprocess	Number of Personnel	Actions per Hour	AWT (Hours)	Total Work Time per Hr	ALT (Hours)	NLT	IT %	TLT (Hours)	NUM	DEN	ROK
Tactical Information Coordinator (TIC)	IDENTIFY											
	Verify EW emissions	1	25	0.00028	0.00694	6.0	5.0	95%	120.0	3000.0	0.0	432.0
	Verify Point of Origin	1	12	0.00028	0.00333	2.0	3.0	95%	40.0	480.0	0.0	144.0
	Match Against ATO	1	20	0.00028	0.00556	2.0	6.0	95%	40.0	800.0	0.0	144.0

Table 27. “To Be” SSDS TIC KVA Analysis

k. AEGIS Identification Supervisor

Table 28 depicts the notional track management core processes involved in the KVA analysis for an IDS aboard an AEGIS platform after reengineering with an open architecture approach.

Billet	Contact ID Subprocess	Number of Personnel	Actions per Hour	AWT (Hours)	Total Work Time per Hr	ALT (Hours)	NLT	IT %	TLT (Hours)	NUM	DEN	ROK
Identification Supervisor (IDS)	IDENTIFY											
	Verify EW emissions	1	25	0.00028	0.00694	6.0	5.0	95%	120.0	3000.0	0.0	432.0
	Verify Point of Origin	1	12	0.00028	0.00333	2.0	3.0	95%	40.0	480.0	0.0	144.0
	Match Against ATO	1	20	0.00028	0.00556	2.0	6.0	95%	40.0	800.0	0.0	144.0

Table 28. “To Be” AEGIS IDS KVA Analysis

l. *SSDS Identification Supervisor*

Table 29 depicts the notional track management core processes involved in the KVA analysis for an IDS aboard an SSDS platform after reengineering with an open architecture approach.

Billet	Contact ID Subprocess	Number of Personnel	Actions per Hour	AWT (Hours)	Total Work Time per Hr	ALT (Hours)	NLT	IT %	TLT (Hours)	NUM	DEN	ROK
Identification Supervisor (IDS)	**IDENTIFY**											
	Verify EW emissions	1	25	0.00028	0.00694	6.0	5.0	95%	120.0	3000.0	0.01	432.0
	Verify Point of Origin	1	12	0.00028	0.00333	2.0	3.0	95%	40.0	480.0	0.00	144.0
	Match Against ATO	1	20	0.00028	0.00556	2.0	6.0	95%	40.0	800.0	0.01	144.0

Table 29. “To Be” SSDS IDS KVA Analysis

G. WATCH STATION COMPARATIVE ANALYSIS

Now that both the “As Is” and “To Be” data have been presented, it is important to present the results in a side-by-side comparison. Each of the watch stations are presented, with % of change in ROK **bolded**. The “Correlate” and “Relay” processes were determined not to have any additional value added through an open architecture approach at this time. Each watch station saw an increased ROK in the “Identify” process, and two had increases in the “Track” process as well. Through an insertion of automation founded on an OA approach, and reduced “AWT”, it was apparent that OA could be used to increase the operational value of a situational awareness system.

Tactical Action Officer	AEGIS "As Is" ROK	AEGIS "To Be" ROK	% Change	SSDS "As Is" ROK	SSDS "To Be" ROK	% Change
CORRELATE	416.43	416.43	**0.00**	138.81	138.81	**0.00**
Obtain Link Information	1728.00	1728.00	0.00	576.00	576.00	0.00
Identify "Same Contact, Multiple Track"	15.43	15.43	0.00	5.14	5.14	0.00
Verify Other Track Sources	19.29	19.29	0.00	6.43	6.43	0.00
TRACK	6.93	10.21	**47.42**	2.31	3.40	**47.42**
Monitor Suspect Tracks	7.71	7.71	0.00	2.57	2.57	0.00
Update Tracks	4.41	4.41	0.00	1.47	1.47	0.00
Update GCCS-M	10.80	432.00	3900.00	3.60	144.00	3900.00
IDENTIFY	216.60	395.97	**82.81**	72.20	130.29	**80.45**
Verify IFF signal	1728.00	1728.00	0.00	576.00	576.00	0.00
Verify EW emissions	25.92	1296.00	4900.00	8.64	432.00	4900.00
Verify Point of Origin	2.16	432.00	19900.00	0.72	144.00	19900.00
Match Against ATO	2.16	432.00	19900.00	0.72	144.00	19900.00
Match Against CommAir Profile	432.00	432.00	0.00	144.00	144.00	0.00
Match Against Intel Information	10.80	10.80	0.00	3.60	3.60	0.00
Examine Kinematic Data	17.28	17.28	0.00	5.76	5.76	0.00
Obtain Visual ID	2.16	2.16	0.00	0.72	0.72	0.00
Conduct Verbal Query	2.16	2.16	0.00	0.72	0.72	0.00
RELAY	7.20	7.20	**0.00**	2.40	2.40	**0.00**
Send Over Links	36.00	36.00	0.00	12.00	12.00	0.00
Discuss Picture with Battle Force Units	4.32	4.32	0.00	1.44	1.44	0.00

Table 30. TAO Final Results

Anti Air Warfare Coordinator	AEGIS "As Is" ROK	AEGIS "To Be" ROK	% Change	SSDS "As Is" ROK	SSDS "To Be" ROK	% Change
CORRELATE	416.43	416.43	**0.00**	138.81	138.81	**0.00**
Obtain Link Information	1728.00	1728.00	0.00	576.00	576.00	0.00
Identify "Same Contact, Multiple Track"	15.43	15.43	0.00	5.14	5.14	0.00
Verify Other Track Sources	19.29	19.29	0.00	6.43	6.43	0.00
TRACK	5.91	5.91	**0.00**	1.97	1.97	**0.00**
Monitor Suspect Tracks	7.71	7.71	0.00	2.57	2.57	0.00
Update Tracks	4.41	4.41	0.00	1.47	1.47	0.00
IDENTIFY	214.57	346.30	**61.40**	71.52	115.43	**61.40**
Verify IFF signal	1728.00	1728.00	0.00	576.00	576.00	0.00
Verify EW emissions	25.92	1296.00	4900.00	8.64	432.00	4900.00
Verify Point of Origin	2.16	432.00	19900.00	0.72	144.00	19900.00
Match Against ATO	2.16	432.00	19900.00	0.72	144.00	19900.00
Match Against CommAir Profile	432.00	432.00	0.00	144.00	144.00	0.00
Match Against Intel Information	10.80	10.80	0.00	3.60	3.60	0.00
Examine Kinematic Data	17.28	17.28	0.00	5.76	5.76	0.00
Obtain Visual ID	2.16	2.16	0.00	0.72	0.72	0.00
Conduct Verbal Query	2.16	2.16	0.00	0.72	0.72	0.00
RELAY	5.24	5.24	**0.00**	1.75	1.75	**0.00**
Send Over Links	36.00	36.00	0.00	12.00	12.00	0.00
Discuss Picture with Battle Force Units	4.32	4.32	0.00	1.44	1.44	0.00

Table 31. AAWC Final Results

Surface Warfare Coordinator	AEGIS "As Is" ROK	AEGIS "To Be" ROK	% Change	SSDS "As Is" ROK	SSDS "To Be" ROK	% Change
CORRELATE	520.68	520.68	**0.00**	173.56	173.56	**0.00**
Obtain Link Information	1728.00	1728.00	0.00	576.00	576.00	0.00
Identify "Same Contact, Multiple Track"	15.43	15.43	0.00	5.14	5.14	0.00
Verify Other Track Sources	19.29	19.29	0.00	6.43	6.43	0.00
TRACK	8.15	92.81	**1038.76**	2.72	30.9	**1038.76**
Monitor Suspect Tracks	7.71	7.71	0.00	2.57	2.57	0.00
Update Tracks	4.41	4.41	0.00	1.47	1.47	0.00
Update GCCS-M	10.80	432.00	3900.00	3.60	144.00	3900.00
IDENTIFY	31.12	68.82	**121.11**	10.37	22.94	**121.11**
Verify IFF signal	1728.00	1728.00	0.00	576.00	576.00	0.00
Verify EW emissions	25.92	1296.00	4900.00	8.64	432.00	4900.00
Verify Point of Origin	2.16	432.00	19900.00	0.72	144.00	19900.00
Match Against Intel Information	10.80	10.80	0.00	3.60	3.60	0.00
Examine Kinematic Data	17.28	17.28	0.00	5.76	5.76	0.00
Obtain Visual ID	2.16	2.16	0.00	0.72	0.72	0.00
Conduct Verbal Query	2.16	2.16	0.00	0.72	0.72	0.00
RELAY	6.11	6.11	**0.00**	2.04	2.04	**0.00**
Send Over Links	36.00	36.00	0.00	12.00	12.00	0.00
Discuss Picture with Battle Force Units	4.32	4.32	0.00	1.44	1.44	0.00

Table 32. SUWC Final Results

Combat Systems Coordinator	AEGIS "As Is" ROK	AEGIS "To Be" ROK	% Change	SSDS "As Is" ROK	SSDS "To Be" ROK	% Change
CORRELATE	104.19	104.19	**0.00**	138.81	138.81	**0.00**
Obtain Link Information	432.00	432.00	0.00	576.00	576.00	0.00
Identify "Same Contact, Multiple Track"	3.86	3.86	0.00	5.14	5.14	0.00
Verify Other Track Sources	5.14	5.14	0.00	6.43	6.43	0.00
TRACK	1.80	1.80	**0.00**	2.26	2.26	**0.00**
Monitor Suspect Tracks	1.93	1.93	0.00	2.57	2.57	0.00
Update Tracks	1.47	1.47	0.00	1.47	1.47	0.00
IDENTIFY	32.80	51.84	**58.02**	34.85	56.70	**62.72**
Verify IFF signal	432.00	432.00	0.00	576.00	576.00	0.00
Verify EW emissions	7.20	360.00	4900.00	8.64	432.00	4900.00
Verify Point of Origin	0.72	144.00	19900.00	0.72	144.00	19900.00
Match Against ATO	0.72	144.00	19900.00	0.72	144.00	19900.00
Match Against CommAir Profile	144.00	144.00	0.00	144.00	144.00	0.00
Match Against Intel Information	3.60	3.60	0.00	3.60	3.60	0.00
Examine Kinematic Data	5.76	5.76	0.00	5.76	5.76	0.00
RELAY	12.00	12.00	**0.00**	12.00	12.00	**0.00**
Send Over Links	12.00	12.00	0.00	12.00	12.00	0.00

Table 33. CSC Final Results

Tactical Informaiton Coordinator	AEGIS "As Is" ROK	AEGIS "To Be" ROK	% Change	SSDS "As Is" ROK	SSDS "To Be" ROK	% Change
CORRELATE	138.81	138.81	**0.00**	138.81	138.81	**0.00**
Obtain Link Information	576.00	576.00	0.00	576.00	576.00	0.00
Identify "Same Contact, Multiple Track"	5.14	5.14	0.00	5.14	5.14	0.00
Verify Other Track Sources	6.43	6.43	0.00	6.43	6.43	0.00
TRACK	1.78	1.78	**0.00**	1.78	1.78	**0.00**
Monitor Suspect Tracks	2.57	2.57	0.00	2.57	2.57	0.00
Update Tracks	1.47	1.47	0.00	1.47	1.47	0.00
IDENTIFY	80.18	114.67	**43.01**	80.18	114.67	**43.01**
Verify IFF signal	576.00	576.00	0.00	576.00	576.00	0.00
Verify EW emissions	8.64	432.00	4900.00	8.64	432.00	4900.00
Verify Point of Origin	0.72	144.00	19900.00	0.72	144.00	19900.00
Match Against ATO	0.72	144.00	19900.00	0.72	144.00	19900.00
Match Against CommAir Profile	144.00	144.00	0.00	144.00	144.00	0.00
Match Against Intel Information	3.60	3.60	0.00	3.60	3.60	0.00
Examine Kinematic Data	5.76	5.76	0.00	5.76	5.76	0.00
Obtain Visual ID	0.72	0.72	0.00	0.72	0.72	0.00
Conduct Verbal Query	0.72	0.72	0.00	0.72	0.72	0.00
RELAY	2.04	2.04	**0.00**	2.04	2.04	**0.00**
Send Over Links	12.00	12.00	0.00	12.00	12.00	0.00
Discuss Picture with Battle Force Units	1.44	1.44	0.00	1.44	1.44	0.00

Table 34. TIC Final Results

Identification Supervisor	AEGIS "As Is" ROK	AEGIS "To Be" ROK	% Change	SSDS "As Is" ROK	SSDS "To Be" ROK	% Change
CORRELATE	138.81	138.81	**0.00**	138.81	138.81	**0.00**
Obtain Link Information	576.00	576.00	0.00	576.00	576.00	0.00
Identify "Same Contact, Multiple Track"	5.14	5.14	0.00	5.14	5.14	0.00
Verify Other Track Sources	6.43	6.43	0.00	6.43	6.43	0.00
TRACK	1.78	1.78	**0.00**	1.78	1.78	**0.00**
Monitor Suspect Tracks	2.57	2.57	0.00	2.57	2.57	0.00
Update Tracks	1.47	1.47	0.00	1.47	1.47	0.00
IDENTIFY	86.30	126.42	**46.49**	86.30	126.42	**46.49**
Verify IFF signal	576.00	576.00	0.00	576.00	576.00	0.00
Verify EW emissions	8.64	432.00	4900.00	8.64	432.00	4900.00
Verify Point of Origin	0.72	144.00	19900.00	0.72	144.00	19900.00
Match Against ATO	0.72	144.00	19900.00	0.72	144.00	19900.00
Match Against CommAir Profile	144.00	144.00	0.00	144.00	144.00	0.00
Match Against Intel Information	3.60	3.60	0.00	3.60	3.60	0.00
Examine Kinematic Data	5.76	5.76	0.00	5.76	5.76	0.00
Obtain Visual ID	0.72	0.72	0.00	0.72	0.72	0.00
Conduct Verbal Query	0.72	0.72	0.00	0.72	0.72	0.00
RELAY	3.88	3.88	**0.00**	3.88	3.88	**0.00**
Send Over Links	12.00	12.00	0.00	12.00	12.00	0.00
Discuss Picture with Battle Force Units	1.44	1.44	0.00	1.44	1.44	0.00

Table 35. IDS Final Results

H. FINAL ROK RESULTS

When combining the ROK for each watch station we can generate a complete picture of the return on knowledge capital invested for each process in both the "As Is" and "To Be" scenarios. This representation better exemplifies the operational value that an OA framework can provide the Navy. Differences in process ROK results across each platform are attributed to the difference in the amount of knowledge required for each of the platforms.

"AS IS" Processes	AEGIS ROK	SSDS ROK
Correlate	1735.35	867.61
Track	26.34	12.81
Identify	661.58	355.43
Relay	36.47	24.10

Table 36. "As Is" ROK Totals

'TO BE" Processes	AEGIS ROK	SSDS ROK
Correlate	1735.35	867.61
Track	114.29	42.13
Identify	1104.02	566.45
Relay	36.47	24.10

Table 37. "To Be" ROK Totals

Difference	AEGIS ROK	SSDS ROK
Correlate	0.00	0.00
Track	**87.95**	**29.32**
Identify	**442.44**	**211.02**
Relay	0.00	0.00

Table 38. ROK Change

Table 38 depicts the dramatic effects that an OA approach can have on the "Track" and "Identify" processes. The ROK indicated that after applying an OA approach efficiency with which knowledge assets are used within these processes dramatically increased.

Knowledge is a key component in the efficient accomplishment of any mission, and therefore provides value to an operational environment. The Department of the Navy, Chief Information Officers' (DON CIO) Information Management/Information Technology (IM/IT) Strategic Plans' stated goal to "build a knowledge sharing culture and exploit new IT tools to facilitate knowledge transfer across the globally distributed enterprise", through "optimizing the effective application of intellectual capital to achieve organizational objectives" (DON CIO, 2001) provides another impetus to use knowledge as a surrogate for value in our core processes.

Increasing the performance of knowledge capital assets within a process provides increased operational value and can have a significant impact on the conduct of naval missions.

THIS PAGE INTENTIONALLY LEFT BLANK

V. CONCLUSIONS

Investments in information technology just for the sake of information technology have put the Navy in a precarious position. Incompatibility, cost overruns and missed opportunities for the efficient use of new technology are often caused through antiquated government standards and application of proprietary approaches to systems design. Leveraging today's technologies with an OA approach can help the Navy realize the full potential of its systems and processes.

This thesis provided insight into the operational value that can be achieved by an OA approach through an increase in the performance of knowledge capital assets, such as situational awareness systems. Through an application of KVA, the value of open architecture can be quantified and processes can be evaluated on a common basis. Through application of KVA, deficiencies and efficiencies can be seen and reengineering efforts can be tailored and prioritized to provide the greatest operational value to the war fighter by the most efficient and effective use of the OA approach.

A. RESEARCH QUESTIONS

The intent of this thesis was to answer the questions proposed in the first chapter. Through a decomposition of the track management process and subsequent analysis using the Knowledge Value Added methodology, the specifics of the questions can now be addressed.

1. Can Open Architecture Improve the Operational Value in a Situational Awareness System?

The underlying foundation of OA, if applied correctly, achieves attributes required for increasing the operational value of such systems. Operational value is sometimes lost in the acquisitions of systems, due in large part to financial and schedule limitations that must be addressed. While an OA approach has been proven in many cases to improve the acquisitions and maintenance cycles, little research is conducted on the operational value of the OA approach in information technology to support core processes. The value of a system to an operator is one that can decrease work time (freeing the operator to conduct other functions); decreased time to learn the system (again, freeing the operator to conduct other tasks); and increase the processing power while decreasing the processing time for each action (providing increased capability and efficiency). This can, in turn, be achieved through proper management of knowledge assets within an organization's core processes.

Hardware that is consistent with the latest technological industry standards provides the greatest processing power with the least amount of latency. Maintaining the ability to upgrade hardware when technology outpaces current systems, without a complete replacement of the system, provides the operator the greatest capability, thereby creating value. In an environment that is not built on an OA foundation, hardware reaches its capacity and functionality limitations and cannot increase its capability through the leveraging of advanced technology. Using COTS equipment, an OA approach can keep pace with technology and thus can maintain the decisive advantage the Navy has come to expect.

Insertion of effective and efficient IT into core processes within a situational awareness process increases the operational value through a decrease in work time for the operator. While proprietary systems can provide the IT resources that will lessen the work load on the operator, they are not flexible enough to integrate with new technologies as they become available. An OA approach will facilitate seamless integration and can thus continue to decrease the work time for an operator when new technology becomes available. The value is created through the continuous insertion of IT assets so that capacity limits in processing power are not expected.

Lastly, the interoperability that is provided through open architecture facilitates faster, more effective transfer of information between sensors and users. Integration of multiple sensors and data resources provides operators greater knowledge that will increase their situational awareness. As IT systems are integrated into core processes, the value of the processes increases through more efficient use of resources.

2. Can KVA be Applied to Current Track Management Systems?

One of the concepts put forth by the DON CIO IM/IT Strategy is that "tacit knowledge is an example of an intellectual asset whose value is only realized when it is actually shared and reused effectively", and that "an organization's ability to innovate, improve, and learn ties directly to that organization's value" (DON CIO, 2001). A means to measure this concept will be fundamental in order to achieve organizational goals and missions in the Navy.

A measurement of value for IT systems and core processes is extremely difficult to obtain for non-revenue generating organizations. In such organizations, cost savings may be an important factor, but the true value of a system should be measured through its ability to produce outputs. KVA can be a valuable tool for assessing the value of current and future track management systems. The measurement of embedded, or tacit, knowledge in core processes is extremely useful when comparing systems. Systems that are of equal capabilities, but require differing amounts of training time and work time can be analyzed and evaluated based on common units of output when using the KVA methodology. Each of the core processes can be decomposed and analyzed as to how well they provide a return on knowledge. Managers are not tied to financial metrics, but rather can justify systems and processes through a quantification of how productively a system or process uses its embedded knowledge.

This methodology is robust and defensible and provides a means for true comparisons of naval systems. The previous chapters provided a critical analysis of the track management systems within the Navy, and showed that KVA is a valuable tool for determining the value for these systems.

3. Can ROK be Used to Determine Areas Where Open Architecture May Provide Increased Efficiency?

Increased ROK does not, in and of itself, constitute improved operational value of a system developed using an OA approach. Analysis of ROK, while important, only describes the relationship between inputs to output for each of the core process within a situational awareness system, and will not describe where future efficiencies or inefficiencies might be obtained through process reengineering. Changes in ROK should be used as a means to identify processes that should be scrutinized for possible optimization of knowledge assets. When ROK's are derived from defensible KVA data, management is provided a tool to analyze performance metrics for knowledge capital assets within the organization, and can make more informed decisions on the application of knowledge assets.

4. Can Real Options Analysis be Used to Support Decisions Regarding Functional Integration of Current Platforms into Future Systems?

The ROK results from the application of the KVA methodology to core processes provide the raw data that is used to determine operational options for systems design and implementation. However, without the accompanying market comparables, it would prove insufficient from an acquisitions viewpoint, as the financial options would not be monetized. When market comparables are integrated into the KVA analysis a more robust determination can be made regarding functional integration for future systems from both an operational and acquisitions perspective. From a strictly operational standpoint, the most prevalent options are listed below:

- Do nothing and allow the "As Is" processes to continue.
- Create and apply middleware solutions to interface between systems built under an open architecture framework to legacy systems. If successful, look to expand to all functional aspects of AEGIS and SSDS platforms.
- Acquire COTS hardware to replace existing legacy components. If successful, look to continue with COTS refresh on a scheduled basis.
- Completely upgrade AEGIS and SSDS platforms to conform to OACE Category 4/5 compliance levels. If successful, apply OA to all future situational awareness systems designs and implementations, and look to expand to other functional areas.

B. RESEARCH LIMITATIONS

The data that was collected and analyzed for this thesis was provided by subject matter experts, both in the operational and training environment. Each SME brings different experiences and levels of expertise to bear on their knowledge estimates provided for this research. The data cannot be assumed perfect. Until automated data capturing methods are in place, and historical data can be retrieved, assessed and analyzed, SME's will continue to be the focal point of this type of analysis.

The "To Be" analysis was based on situations that SME's determined to be the best areas where open architecture could provide value to the operator. While process reengineering ideas were constructed, the technical and legal aspects of the "To Be" analysis were avoided in order to provide a conceptual idea rather than a practical one. Application of current legal parameters, technical constraints and budgetary limitations would be needed in order to form a more practical solution.

THIS PAGE INTENTIONALLY LEFT BLANK

VI. RECOMMENDATIONS

This thesis explored the possibilities for using KVA as a methodology to measure the operational effectiveness of an open architecture approach to systems design. Looking at a notional reengineering effort founded on the principles of open architecture, as laid out by the PEO IWS, Open Architecture Division, there are definite advantages to be gained through open architecture and the use of KVA as a management tool. Changing the underlying way that systems are developed and implemented is a huge undertaking and will require a fundamental change in the way the Navy conducts business. The Navy has begun the process of change through the creation of the OA Division in PEO IWS. This first step was vital for the success of current and future naval systems in the area of interoperability and upgradeability, but additional research will be necessary to facilitate a seamless transition.

A. RECOMMENDED CHANGE

Realizing the value of an open architecture approach to systems design will require data capturing mechanisms that are not currently available. The KVA analysis, and any other for that matter, is only as good as the data used for analysis. For a complete analysis of OA, the following recommendations are provided:

- Initiate efforts to include KVA analysis for core processes within situational awareness systems.
- Define core processes and monitor the learning time and work time required to accomplish these processes. As the data becomes more comprehensive, the results will better reflect actual processes as they are being conducted.
- Create and update a repository of market comparables so that future financial analysis of KVA results can tap into a historical library of commercial sector functions that could match the process being analyzed.

B. FOLLOW-ON RESEARCH

With the foundation being laid, there is still much research required in the area of measuring and determining the value of open architecture. The acquisition community could especially benefit from an open architecture approach to systems design, through software reuse, scalability and interoperability. For this community to embrace the tenets and attributes of open architecture, further research is required.

First, market comparables should be researched and applied to the results of any KVA analysis. This thesis focused on the operational value of an open architecture, but to the acquisition community it is imperative to provide a surrogate for financial returns. Market comparables provides this through 1) a comparison of similar processes from the commercial sector; 2) comparing this process with the comparable non-profit or governmental process being analyzed; 3) determining the revenue associated with the commercial process; 4) applying the revenue estimates to the non-profit or governmental process to determine what price (revenue) the commercial sector is getting for similar process outputs. This type of research will be vital for the continued movement of OA into the mainstream acquisition community due to the fact that KVA analysis can be monetized. Having a means to see a financial impact on the design, operation and maintenance of an OA system could prove to be a key element of implementing OA throughout the Navy's core processes.

Second, an analysis on the maintainability of OA systems should be conducted. This area should prove to be the most important in the area of value when using an open architecture approach to systems design. Through its ability to rapidly scale, upgrade and modify, a system founded on OA principles can have the potential to see huge savings in maintainability. Providing an analysis in this area could provide an important rationale for the continued use of open architecture. Providing a KVA and market comparables analysis on the maintainability of systems created through an OA framework is the next step in providing a well-rounded analysis of OA.

Lastly, a KVA analysis of the entire AEGIS and SSDS systems could provide insight into areas that would not be fully realized through an analysis of only one component of the systems in a process. This thesis examined the area of track management, but that is only one facet of the overall systems aboard naval vessels. Command and control, decision support, sensor inputs and a myriad of other components that comprise the overall systems on naval ships should be analyzed concurrently so that possible benefits, which may have gone unnoticed when focusing on one component, can be realized. When systems are examined through a complete analysis, interface and interoperability issues can be discerned and addressed.

THIS PAGE INTENTIONALLY LEFT BLANK

LIST OF REFERENCES

Alberts, D., J. Garstka, R. Hayes, D. Signori, *Understanding Information Age Warfare,* C4ISR Cooperative Research Program, August 2001.

Alberts, D., J. Garstka, F. Stein, *Network Centric Warfare: Developing and Leveraging Information Superiority, 2nd Edition (Revised),* C4ISR Cooperative Research Program, February 2000.

Azani, C., "The Test and Evaluation Challenges of Following an Open System Strategy." *ITEA Journal*, September/October 2001 (Volume 22, Number 3).

Clark, V., "Sea Power 21: Projecting Decisive Joint Capabilities*.*" *Proceedings,* October 2002.

Cohen, W., *Annual Report to the President and the Congress, Appendix K*, Department of Defense, 1999.

Defense Acquisition University, *Defense Acquisition Guidebook*, 2004.

Department of the Navy, Chief Information Officer, *Metrics Guide for Knowledge Management Initiatives,* 2001.

Department of the Navy Memorandum, *Naval Open Architecture Scope and Responsibilities*, 5 August 2004.

Department of the Navy, NAVSEA, PEO IWS, Open Architecture, *Open Architecture (OA) Computing Environment Design Guidance, Version 1.0.,* 23 August 2004.

Department of the Navy, NAVSEA, PEO IWS, Open Architecture, *Open Architecture (OA) Computing Environment Technologies and Standards, Version 1.0.,* 23 August 2004.

Edenfeld, D., Johnson, J. "Enabling the Vision: Deployment of an Open Architecture Tester," *Intel Corporation*, 2005.

Federal Enterprise Architecture Program Management Office, *Performance Reference Model*, *Version 1.0, Volume II,* 2003.

Global Command and Control System-Maritime (GCCS-M) Navy Training System Plan (N6-NTSP-E-70-9804 JMCIS '98/GCCS-M), retrieved May 2006, from http://www.fas.org/man/dod-101/sys/ship/weaps/docs/gccs-m-ntsp/index.html, July 1998.

Government Accountability Office Report GAO-06-211, *Defense Acquisitions: DOD Management Approach and Processes Not Well-Suited to Support Development of Global Information Grid*, 2006.

Housel, T., A. Bell, *Measuring and Managing Knowledge*, McGraw-Hill, 2001.

Information Technology Management Reform Act of 1995.

Knowledge Value-Added (KVA) Methodology, *International Engineering Consortium*, retrieved May 2006, from http://www.iec.org/online/tutorials/kva/.

Mayo, R., J. Nathman, "ForceNet: Turning Information into Power." *Proceedings*, February 2003.

Mun, J., *Real Options Analysis, Tools and Techniques for Valuing Strategic Investments and Decisions,* John Wiley & Sons, Inc., 2002.

National Research Council, Committee on the FORCEnet Implementation Strategy, *FORCEnet Implementation Strategy,* National Academies Press, 2005.

Open Systems Joint Task Force, *A Modular Open Systems Approach (MOSA) to Acquisition Program Manager's Guide, Version 1.1.*, retrieved May 2006, from http://www.acq.osd.mil/osjtf, August 2003.

Ricci, L., "Open Standards Cut Costs, Increased Features for OEM Equipment Builders," *Applied Data Systems, Inc*., 2003.

Rice, M., M. Russell, Open Architecture: An Enterprise Approach to Introducing Open Architectures Into Navy Combat Systems… and Beyond, *E-Gov Conference Presentation*, February 2004.

Simons, R., Winkler, A., "Open Architecture Tutorial," *Computer Science Corporation*, 2004.

Strei, J., *Open Architecture in Naval Combat System Computing of the 21st Century*, Washington Navy Yard, 2003.

INITIAL DISTRIBUTION LIST

1. Defense Technical Information Center
   Ft. Belvoir, Virginia

2. Dudley Knox Library
   Naval Postgraduate School
   Monterey, California

3. Marine Corps Representative
   Naval Postgraduate School
   Monterey, California

4. Director, Training and Education, MCCDC, Code C46
   Quantico, Virginia

5. Director, Marine Corps Research Center, MCCDC, Code C40RC
   Quantico, Virginia

6. Marine Corps Tactical Systems Support Activity (Attn: Operations Officer)
   Camp Pendleton, California

7. NAVSEA
   PEO IWS (1A)
   Open Architecture
   Washington Navy Yard, Washington D.C.

8. Dr. Dan Boger
   Naval Postgraduate School
   Monterey, California

9. Dr. Thomas Housel
   Naval Postgraduate School
   Monterey, California

10. Glenn Cook
    Naval Postgraduate School
    Monterey, California